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United States
Department of
Agriculture

Forest Service
Southern Region

Final Environmental Impact Statement

VEGETATION MANAGEMENT in the Appalachian Mountains

VOLUME I

Management Bulletin R8-MB 38

July 1989

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COMMENTS ON THE METRIC SYSTEM

The metric system is used to describe weights and measures. It is a decimal system -- units are consistantly named to reflect multiplication or division of the basic unit by some power of 10 (10, 100, 1000, etc.). The two basic defined units of this system are the meter and the kilogram. All other units (volume, area, etc.) are calculated based on these two.

Metric measurement is the standard for scientific communication worldwide. It has been selected in preference to many other systems including the English system of measures which is in common use in the United States. Below is a table which will help readers of this Risk Assessment understand the metric numbers presented throughout the text.

ABBREVIATIONS
(Metric and English)

ac = acre
cc = cubic centimeter
cm = centimeter
ft = foot
g = gram
ha = hectare
in = inch

kg = kilogram
km = kilometer
l = liter
lb = pound
m = meter
mg = milligram
mi = mile

ml = milliliter
mm = millimeter
ppm = parts per million
oz = ounce
qt = quart
um = micrometer

CONVERSIONS

Length:

METRIC to ENGLISH

1 km (1,000 m) == 0.6214 mi
1 m == 39.37 in
1 cm (.01m) == 0.394 in
1 mm (.001m) == 0.0394 in
1 um (.000001m) == 0.000039 in

ENGLISH to METRIC

1 mi == 1.609 km
1 ft == 0.305 m
1 in == 2.54 cm

Mass / Weight:

1 kg (1,000 g) == 2.2046 lb
1 g == 0.035 oz
1 mg (.001 g) == 0.000035 oz
1 ug (.000001 g) = 0.000000035 oz

1 lb == 453.592 g
1 oz == 28.35 g

Others:

1 l == 1.056 qt (liquid)
1 ha == 2.471 ac
1 kg/ha == 0.89 lb/ac

1 qt == 1.136 l
1 ac == 0.40 ha
1 lb/ac == 1.12 kg/ha

Final Environmental Impact Statement for

VEGETATION MANAGEMENT

in the Appalachian Mountains

USDA Forest Service
Southern Region

Alabama, Georgia, Kentucky, North Carolina, South Carolina,
Tennessee, Virginia, West Virginia

Responsible Agency

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Abstract

This environmental impact statement presents 10 alternative ways to manage vegetation on Appalachian Mountains national forests of the USDA Forest Service's Southern Region. These alternatives range from no treatment to maximum vegetation control. Treatment alternatives use different mixes of methods and vary numbers of acres treated so as to present a wide array of possible approaches. Effects of each alternative on the physical and biological environment and on social and economic conditions are presented. Alternative Modified D is the Forest Service's preferred alternative.

Note to Reviewers

Reviewers should provide the Forest Service with comments during the review period. This will enable the Forest Service to analyze and respond to comments at one time and to use the information to prepare the final environmental impact statement, thus avoiding undue delay in the decision-making process. Reviewers have an obligation to structure their participation in the National Environmental Policy Act process so that it is meaningful and alerts the agency to reviewers' positions and contentions, Vermont Yankee Nuclear Power Corp. V. NRDC, 435 U.S. 519, 553 (1978). Environmental objections that could have been raised at the draft stage may be waived if not raised until after completion of the final environmental impact statement, Wisconsin Heritages, Inc. v. Harris, 490 F. Supp. 1334, 1338 (E.D. Wis. 1980). Comments should be specific and should address the adequacy of the statement or merits of the alternatives discussed.

PREFACE

Over 580 people, groups, and agencies commented to us about the Draft EIS. Their comments and our responses are in volume III. Based on these comments, we made several changes from the Draft to the Final EIS. The more important changes are described below.

In **chapter I**, we expanded section B (Need for Action) to discuss relationships between objectives and treatments for each vegetation management activity. In addition, section B describes the interaction of timber harvest methods and related vegetation management treatments. We added these discussions to improve the public's understanding of vegetation management's role on the national forests.

In **chapter II**, we modified alternative D, the preferred alternative in the Draft EIS. The revision (1) reduces projected herbicide use from 34,149 to 29,335 acres per year; (2) reduces projected aerial herbicide application from 900 to 400 acres per year for use only on major utility lines in rugged, remote, and uninhabited terrain where other methods are not practical; and (3) increases from 75 to 85 percent the herbicide treatments that must be applied selectively. This alternative (**MODIFIED D**) responds to those who are concerned about potential adverse effects of herbicide use, especially by aerial and other broadcast means, in the preferred alternative. Finally, we developed two alternatives suggested by public comment; one was considered but eliminated from detailed study, and the other alternative (**Modified E**) is analyzed in detail. See sections II.B and II.C.

Also in **chapter II**, we added several mitigation measures and strengthened others. Examples are:

- Use only class A (least risk) herbicides, with rare exceptions requiring the Regional Forester's approval.
- Remove workers with confirmed sensitivity to herbicides from herbicide projects.
- Use selected mineral oil formulations that have lower environmental risks as a herbicide additive instead of diesel oil whenever feasible.
- Increase buffers on each side of streams, trails, and roads to at least 200 horizontal feet when herbicides are applied on utility rights-of-way.
- Report vegetation management programs of each national forest annually and review them periodically to ensure that methods and mitigation measures are implemented as planned.
- Develop critical values for drought indices for major vegetation-soil-landform types to assure prescribed burning will occur only on days when the drought code is less than the critical value.

We made these and numerous other changes to respond to those who questioned the efficacy of our mitigation measures to protect people and the environment.

In **chapter IV**, we expanded some analyses of environmental effects. For example, health effects of mineral oil and of burning herbicide-treated plants are disclosed based on expanded analysis in section B. Effects of herbicides and mechanical methods on water quality are discussed in more detail in section G. Effects of each alternative on soil, water, and air are put in perspective in section N.

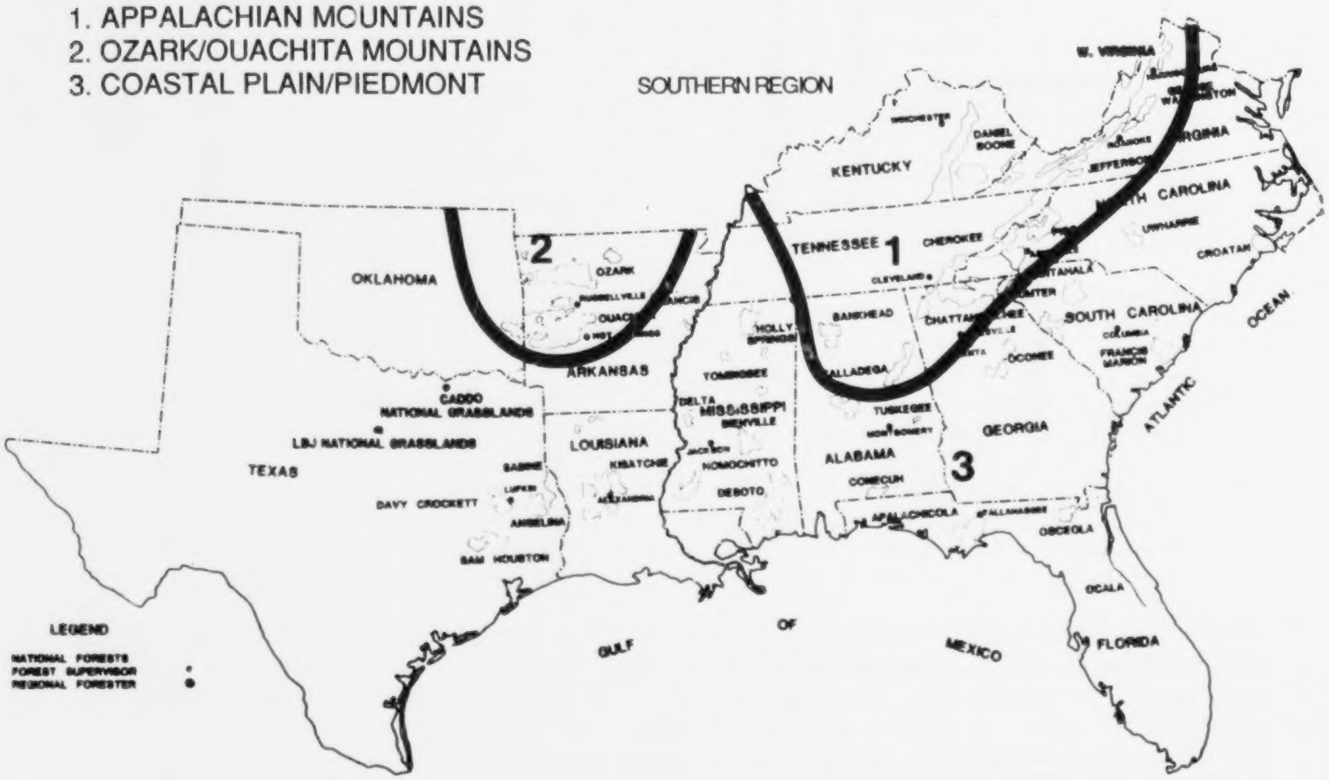
In **appendix A**, we added a supplement analyzing potential health effects of various mineral oil formulations. In **appendix F**, we updated the lists of threatened, endangered, proposed, and sensitive species. The revised lists reflect the most current information from State and Federal agencies. We expanded the biological evaluation for added species, in **appendix D**.

Only sections of the appendices that required revision were reprinted in the Final EIS. A complete set of appendices is available for review at this office and Forest Service field offices in the Appalachian Mountains area.

SUMMARY

Introduction

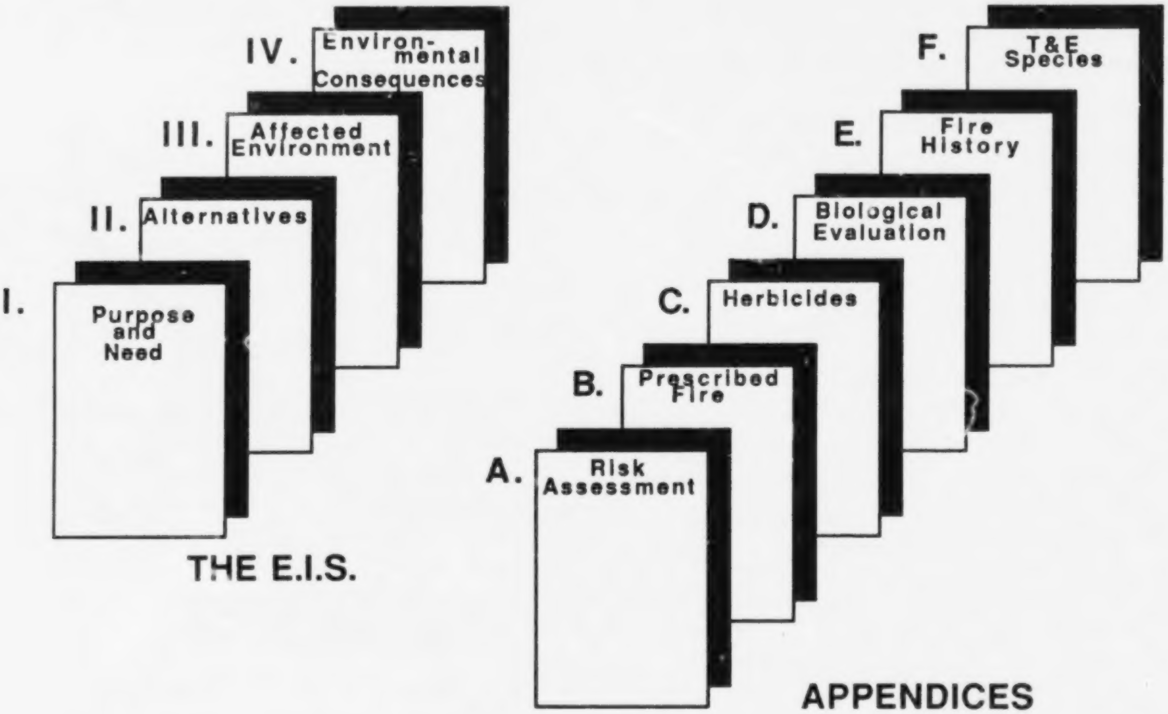
This summary is an introduction to the Environmental Impact Statement (EIS) for vegetation management on national forests in the Appalachian Mountains. This area includes all of Kentucky, Tennessee, and Virginia, and parts of Alabama, Georgia, North Carolina, South Carolina, and West Virginia.


1. APPALACHIAN MOUNTAINS
2. OZARK/OUACHITA MOUNTAINS
3. COASTAL PLAIN/PIEDMONT
SOUTHERN REGION
1
2
3
W. VIRGINIA
VIRGINIA
KENTUCKY
DANIEL BOONE
JEFFERSON
NORTH CAROLINA
UWHARRIE
CROATAN
TENNESSEE
CHEROKEE
OKLAHOMA
OZARK
ARKANSAS
SOUTH CAROLINA
FRANCIS MARION
OCONEE
HOLLY SPRINGS
TOMBIGBEE
DELTA
MISSISSIPPI
BIENVILLE
HOMOCHITTO
DESOTO
BANKHEAD
TALLADEGA
TUSKEGEE
ALABAMA
CONECUH
GEORGIA
APALACHICOLA
OSCEOLA
OCALA
FLORIDA
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
TEXAS
LOUISIANA
KISATCHIE
SABINE
DAVY CROCKETT
ANGELINA
SAM HOUSTON
ATLANTIC
OCEAN
GULF
OF
MEXICO
LEGEND
NATIONAL FORESTS
FOREST SUPERVISOR
REGIONAL FORESTER

Vegetation management is the skillful care of plants by means other than timber harvest. It is done to help young trees survive and grow, to provide a variety of wildlife habitats, to maintain mountaintop balds and recreation areas, to reduce hazardous fuels, and to maintain safe and efficient travelways and utility lines.

The EIS analyzes effects of vegetation management methods on human health and safety, wildlife, threatened and endangered species, vegetation, soils, water and aquatic animals, air, visual quality, cultural rersources, wildfire, recreation, and social and economic conditions. Based on issues raised by the public in the development and review of the Draft EIS (Draft) 10 alternatives were evaluated. Each differ with respect to acres treated, mix of methods, and intensity of tools available. **Modified D** was developed as result of public comment and is within the full range of actions and effects of the other alternative disclosed in the Draft. It is the preferred alternative. It has a small increase in the use of herbicides from current but reduces its use from the Draft. It requires the use of least risk (Class A) herbicides and increases selective applications with priority on techniques that pose minimum risk and exposure to humans, wildlife, and non-target plants. The criteria for aerial application of herbicides on utility right-of-way corridors is more restrictive than in the Draft. Acres available to treat annually by aerial method in the Final EIS are reduced by approximately 60 percent. This reduction is reflected by increases in manual and mechanical methods. The use of low-moderate intensity prescribed fire and biological (livestock grazing) methods remain at about the same levels.

Chapters I through IV form the heart of the EIS. Chapter I defines the need for vegetation management and displays issues. Chapter II explains each alternative, describes methods and tools, prescribes measures to mitigate environmental effects, and compares alternatives. Chapter III describes the environment of the Appalachian Mountains. Chapter IV presents detailed analyses of environmental effects based on extensive scientific research. This summary presents highlights of these chapters.



The EIS also contains six major appendices that were included in the Draft. However, to reduce duplication, only amendments resulting from review of the Draft are included in the Final EIS. The entire volume of Appendices is available for review at this office. Appendix A is the Risk Assessment, a complex scientific document that analyzes herbicide risks to human and wildlife health. These risks are a product of the potency of each chemical and the degree of exposure to it. The evaluation compares herbicide doses people and animals may get with doses shown to be safe in laboratory studies. Each herbicide is analyzed for its potential to cause toxic and other effects such as cancer, mutations, and birth defects. Appendices B and C discuss the effects of prescribed fire and herbicides on soil and water. These appendices contain large bodies of research data under one cover and thus improve accessibility for readers. Appendix D is a biological evaluation of the effects of the preferred alternative on threatened, endangered, proposed and sensitive species. Appendix E is an analysis of the history, uses, and effects of fire in the Appalachians. Appendix F lists proposed, threatened, endangered, and sensitive species.

Scope of Decisions

The Southern Region contains a variety of landscapes, plant communities, soil types, and climates. To account for some of these differences, the Region is divided into three areas to analyze vegetation management activities. This EIS covers the Appalachian Mountains area. Other EIS's cover the Coastal Plain/Piedmont and Ozark/Ouachita Mountains.

This EIS accepts the land allocation and resource output decisions of Forest Land and Resource Management Plans. It evaluates various vegetation management methods and tools needed to achieve Plan goals and objectives. The makeup of methods, tools, and mitigation measures in the selected alternative may require some changes in Plan direction.

The EIS analyzes general effects over broad areas. Since environmental conditions can vary greatly from site to site, each project must be evaluated for its own site-specific effects. Site-specific analyses may reference (tier to) this EIS and EIS's accompanying Plans as appropriate. Methods and tools available for use on the ground are limited to those specified in the selected alternative.

Public Issues

About 700 people responded to a request to help identify five issues the EIS should address. These issues form the basis for developing and comparing alternatives. They express multiple concerns and values, many of which are opposed to each other.

Balance of Resources: At issue is the mix of resources and outputs produced. Some people believe that an increase in market outputs like timber conflicts with an increase in non-market outputs like aesthetics.

Prescribed Fire: This method is generally viewed as "natural" and needed for wildlife, some ecosystems, and wildfire control. Concern centers on season, frequency, and intensity of prescribed fires as they affect soil, water, air, and desirable hardwoods.

Communications: This issue involves how well the Forest Service explains its programs. The issue applies only indirectly to vegetation management. By fully disclosing effects, the EIS helps address this issue.

Herbicides: Many people fear that herbicides have serious effects on human health and on non-target plants and animals, or that they may have adverse effects on drinking water and aquatic communities. Some people fear that aerially applied herbicides increase risk to human health and non-targets. Others view it as essential for economical treatment of some areas.

Mechanical Treatments: People suggest mechanical treatments should be used more to provide employment and to minimize effects caused by other methods such as prescribed fire and herbicides. Possible adverse effects on soils, water, and aesthetics are of concern.

Affected Environment

This EIS covers 5.2 million acres on 10 national forests in the Appalachian Mountains. The Appalachian Mountains are comprised of three physiographic provinces: the Blue Ridge, Ridge and Valley, and Appalachian Plateaus. The Blue Ridge is a rugged highland of steep, rounded mountains of old metamorphic and igneous rocks. Ridge and Valley is comprised of parallel ridges and valleys mostly of folded sedimentary rocks. Appalachian Plateaus are along the western edge and are young uplands of flat-lying sedimentary rocks.

Major vegetation groups are the oak-hickory-pine (loblolly-shortleaf pine) forests, mixed mesophytic forests, and Appalachian oak forests. There are 26 animal species and 6 plant species classified as threatened or endangered or proposed for listing. Soils are as varied as the geology and climate of the mountains, ranging from deep fertile soils in coves and floodplains to soils severely eroded by past, inefficient farming, mining and logging. Water is usually abundant and of high quality. High yielding aquifers, however, are found principally in large river valleys and areas underlain by limestone.

Vegetation management is presently done on an average of 130,045 acres per year, or 2.5 percent of national forest lands in the Appalachian Mountains. Of this total, 44,807 acres (34.5 percent) are now treated with prescribed fire; 24,859 acres (19.1 percent) with mechanical methods; 24,494 acres (18.8 percent) by herbicides; 33,048 acres (25.4 percent) with manual methods; and 2,837 acres(2.2 percent) by biological methods.

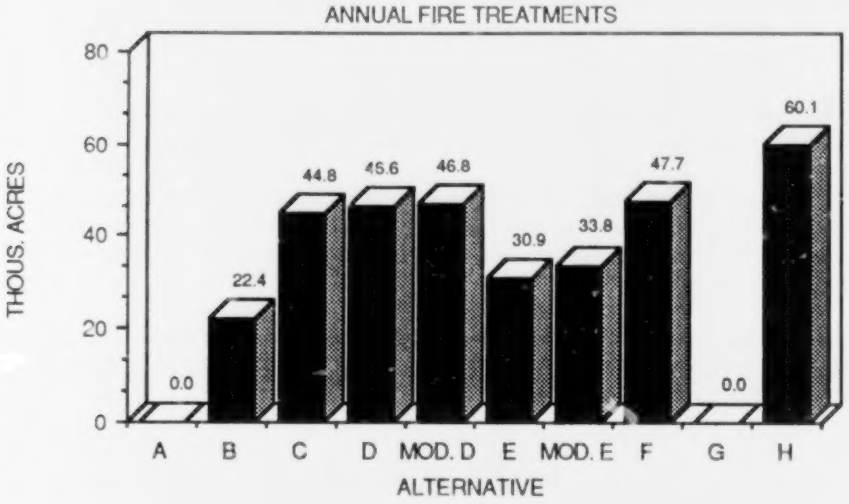
Vegetation Management Methods and Tools

The five methods evaluated by the EIS are prescribed fire, mechanical, manual, biological, and herbicides. The mix of these methods varies markedly by alternative.

Prescribed Fire

Prescribed fire is the planned use of fire under specific conditions. Six firing techniques are used that vary how a fire is set in relation to the wind. Prescribed fires may be set by hand using drip torches or by using helicopters.

In general, light to moderate burns retain an effective ground cover of scorched or charred litter. Severe burns consume all litter and duff and alter the color and structure of mineral soil.



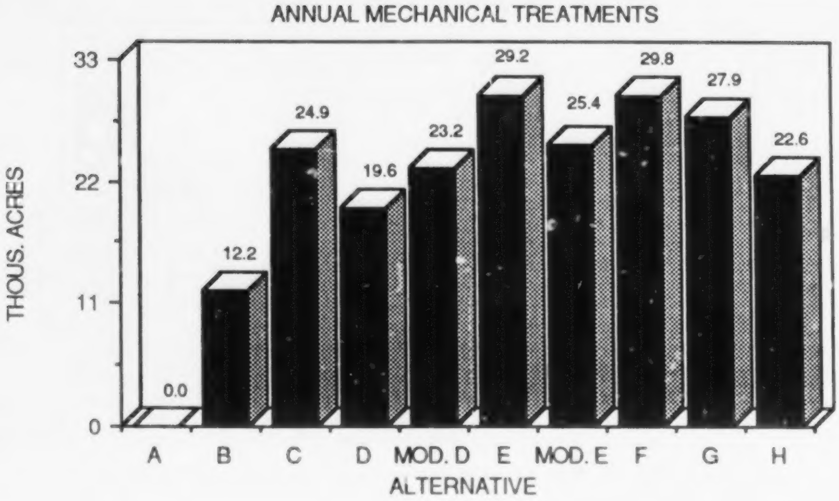
Mechanical Methods

Mechanical methods involve the use of ground machines. They are classed into three groups based on their potential for soil disturbance by erosion, compaction, and nutrient loss.

Mowing tools cut small vegetation above ground. Chopping tools are bladed drums that roll over and chop vegetation. Shearing tools are tractor-mounted blades that cut vegetation above ground. Scarifying tools scoop small depressions in the soil at wide intervals. Ripping tools plow furrows at wide intervals. Mowing, chopping, shearing, scarifying, and ripping cause low soil disturbance.

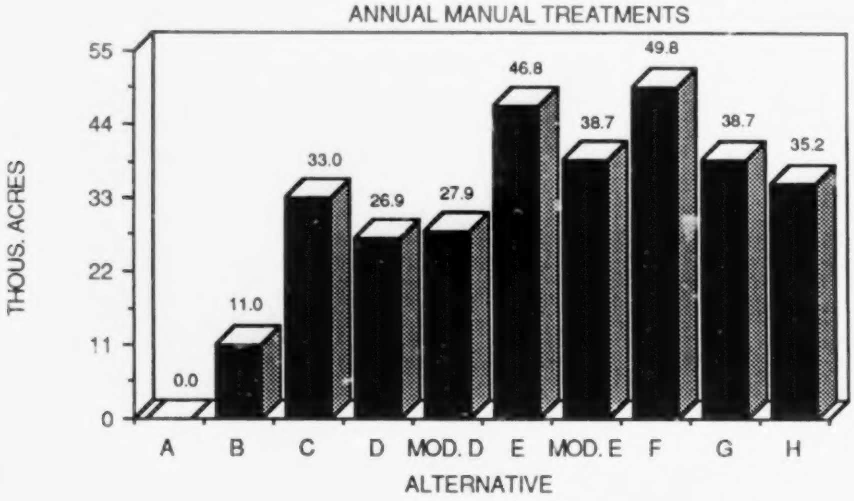
Piling causes moderate soil disturbance. Piling tools replace the dozer blade on tractors and roll vegetation, slash, and some litter into piles or windrows.

Raking and disking cause high soil disturbance. Unlike piling tools, raking tools push all litter and some topsoil into piles or windrows. Disking loosely tills soil.



Manual Methods

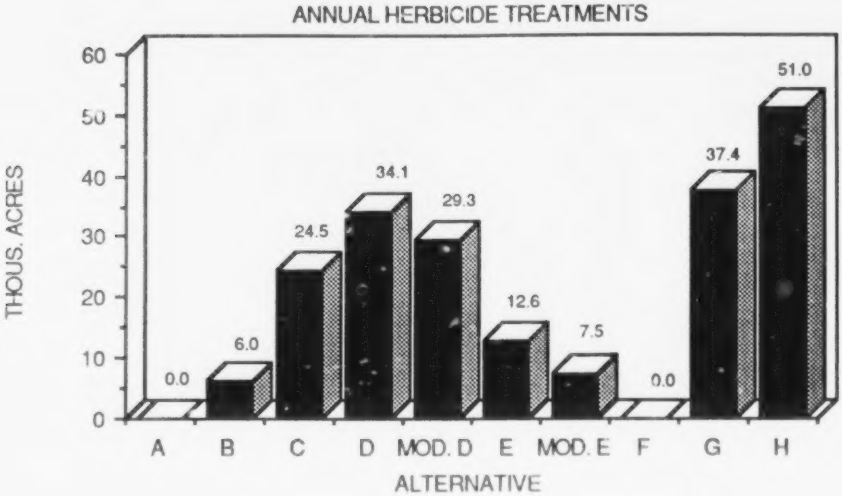
Manual methods employ hand tools to cut vegetation above ground. Non-power tools are axes, brush hooks, and clippers. Power tools include chain saws and brush cutters.



Herbicides

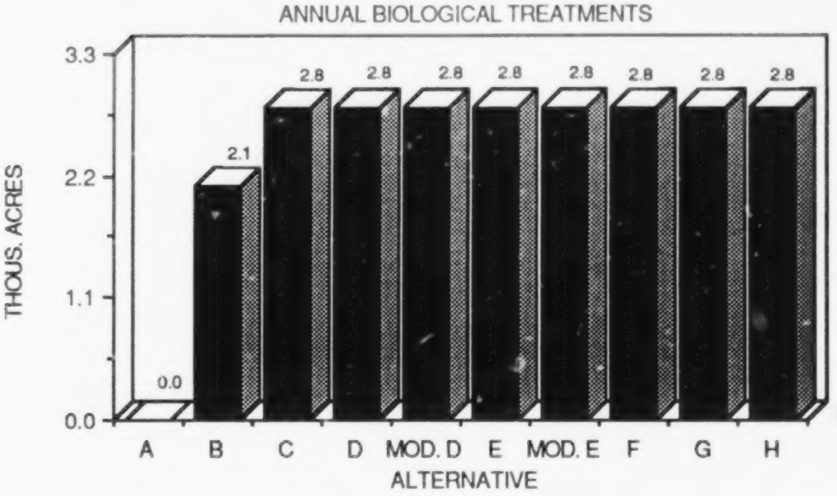
The 11 herbicides evaluated for use in the Southern Region are dicamba; fosamine; glyphosate; hexazinone; imazapyr; picloram; sulfometuron methyl; tebuthiuron; triclopyr; 2,4-D; and 2,4-DP. In addition, four additives (diesel oil, kerosene, limonene, and mineral oil), were analyzed for their effects on human and wildlife health.

Herbicides are used to kill or suppress target plants. They are applied in liquid or granule form by hand, machine, or air. Hand applications use backpack sprayers and tree injectors for liquids and hand-held spreaders for granules. Machine and helicopter applications use boom/nozzle sprayers for liquids and power spreaders for granules.



Biological Methods

The only biological method evaluated is the use of livestock for balds management.



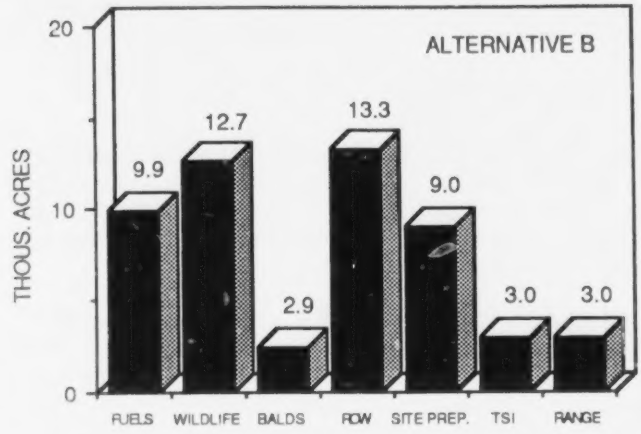
Alternatives

Ten alternatives were developed to respond to issues. They vary by acres treated per year, mix of methods, and intensity of tools used in each method.

Alternative A (No Action)

Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Alternative B



Vegetation management is restricted to treatments which achieve minimum resource objectives. All activities receive treatments, but only when critically needed, and at low intensity. Acres treated per year total 53,776. Use of herbicides and biological methods is minor.

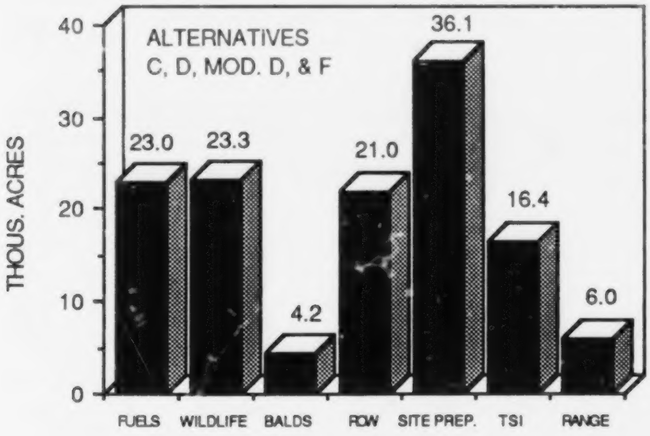
Herbicides are applied by hand. When they are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants. Mechanical treatments are limited to low-disturbance tools. Only low-intensity, less frequent prescribed fire is used.

Alternative C

This alternative continues present levels of treatment specified in Forest Land and Resource Management Plans. Acres treated per year total 130,045. Use of all methods except biological is fairly extensive, with prescribed fire and manual dominating.

Herbicides are applied by hand and machine. Mechanical methods cause low to high soil disturbance. Prescribed fire is low to high intensity. Grazing is used to maintain some balds. All sorts of manual treatments are done.

Alternative D



Prescribed fire, herbicides, and manual are the major means of vegetation control. Acres treated per year total 130,045. Herbicides increase from present by 9,655 acres, prescribed fire by 1,746 acres, and mechanical methods decrease by 5,290 acres; manual decreases by 6,111 acres. Use of biological methods is moderate.

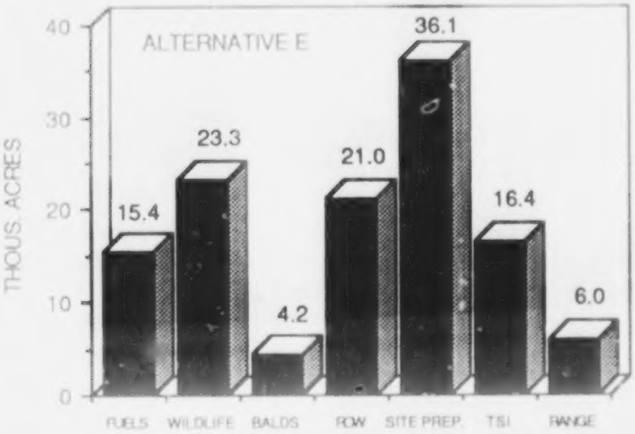
Herbicides are applied by hand, ground machines, and helicopter. When herbicides are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife and non-target plants. Herbicides are applied aerially on 900 acres of utility and gas lines per year. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity.

Alternative Modified D (Preferred)

All methods are available emphasizing prescribed fire and herbicides slightly more than present but less than alternative D. Acres treated per year total 130,045. Herbicide use increases by 4,841 acres and fire use by 1,946 acres. Offsetting decreases occur in use of manual and mechanical. Use of biological methods is limited to grass balds. This alternative was developed as a result of comments to the Draft EIS and falls within the full range of actions and effects of the alternatives discussed in the Draft EIS.

Herbicides are applied by hand, ground machines, and helicopter. When herbicides are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants. Area treated by herbicides selectively vs. broadcast is reduced 25 percent from current (alternative C) and 50 percent from alternative D. Herbicides are applied aerially on 400 acres of utility corridors per year. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity.

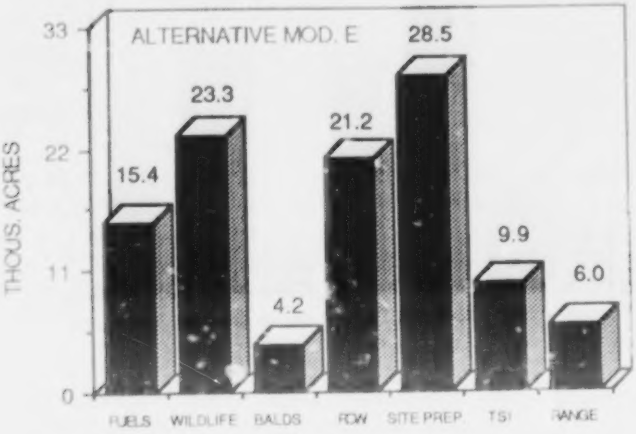
Alternative E



Manual and mechanical methods are the major means of vegetation control. Acres treated per year total 122,367. Manual treatments increase from present by 13,796 acres, and mechanical treatments increase by 4,332 acres. Use of biological methods is moderate, and prescribed fire and herbicides are deemphasized.

When herbicides are used, priority is given to herbicides and application methods that pose minimum risk to humans, wildlife, and non-target plants. Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity. The full range of manual tools and treatments is available.

Alternative Modified E



Use of herbicides and prescribed fire are severely restricted. Pine site preparation and TSI are also reduced. Total acres treated annually are 108,328. Use of biological methods is moderate. Manual treatments increase from current by 5,649 acres.

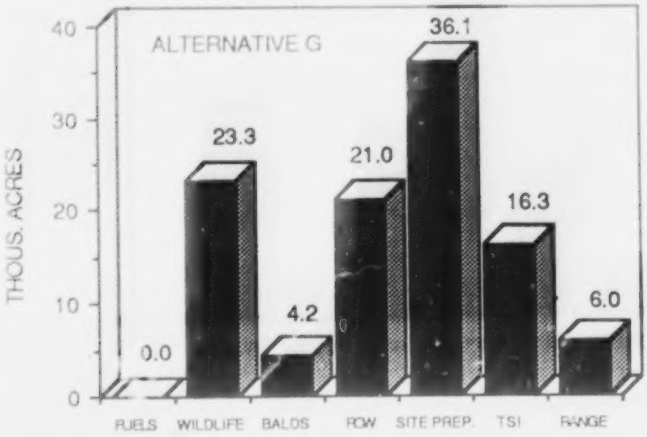
When herbicides are used priority is given to herbicides and application methods that pose minimum risk to humans, wildlife, and non-target plants. Merchanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity. The full range of manual tools and treatments is available. As a result of comments received from the Draft EIS this alternative was developed for those who desired a severe reduction of prescribed fire and herbicides and an increase in manual methods. It is similar to alternative E and falls within the range of actions and effects of the other alternatives disclosed in the DEIS.

Alternative F

Herbicides are not used. Acres treated per year total 130,045. Manual and mechanical treatments increase from present by 16,717 and 4,927 acres, respectively, to replace herbicides. Use of biological methods is moderate.

Mechanical methods cause low to moderate soil disturbance. Prescribed fire is low to moderate intensity. All sorts of manual treatments are done.

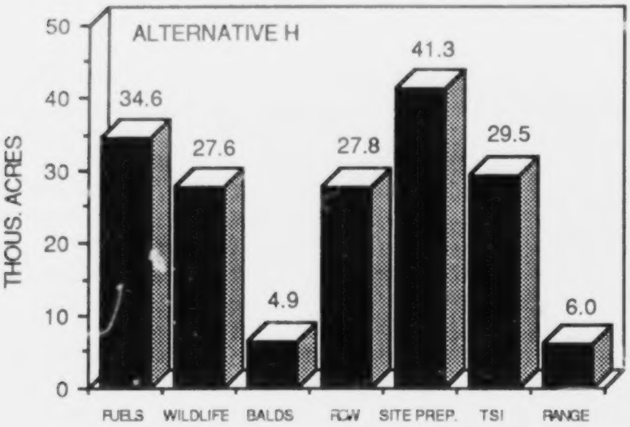
Alternative G



Prescribed fire is not used. Most treatments (except fuel reduction) are at Forest Land and Resource Management Plan frequencies. Intensity of mechanical treatments is reduced. Acres treated per year total 106,912. Emphasis is on herbicides and manual methods, and use of biological methods is moderate.

When herbicides are used, priority is given to herbicides and application methods that pose minimum risks to humans, wildlife, and non-target plants. Herbicides are applied aerially on 2,100 acres per year. Mechanical methods cause low to moderate soil disturbance.

Alternative H



Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates, and intensive mechanical methods and prescribed fire are favored. Acres treated per year total 171,671. Emphasis on herbicides increases markedly from present.

Herbicides are applied by hand, ground machines, and helicopter. Herbicides are applied aerially on 8,700 acres per year. Mechanical methods cause low to high soil disturbance. Prescribed fire is low to high intensity.

Management Requirements and Mitigation Measures

Management requirements and mitigation measures are "do's" and "don't's" applied on the ground to assure that treatments accomplish their objectives and produce fewer adverse impacts and more benefits. They are the heart of this EIS. Some requirements and measures are general and apply to all vegetation management methods. Others pertain to only one method. Analysis shows they significantly reduce adverse environmental effects. Chapter II covers them in detail and discusses their effectiveness. They are summarized below.

General

Detailed site-specific analyses, biological evaluations, and Integrated Pest Management (IPM) principles are required for each project. Water quality is protected from non-point pollution through use of Best Management Practices (BMP's). Timber stand improvement guides ensure adequate tree stocking and forest health. Stream stability is protected by retaining bank vegetation and preventing debris deposits. Cultural resources are inventoried and protected. Safety equipment is mandated for field workers. Methods and tools are matched to visual quality objectives, and treatments are timed to protect scenic values. Vegetation is treated to enhance variety of wildlife habitat. Corridors are managed to control erosion, protect public safety and facilities, and enhance wildlife, recreational and visual values. Threatened, endangered, proposed, and sensitive species, unique features of mountaintop balds, and public use of recreation areas are protected.

Prescribed Fire

Timing and intensity of burns are controlled to protect crop and wildlife trees and nesting animals, limit soil damage, and reduce erosion, sediment loads, and smoke emissions. Firelines are built and maintained to reduce erosion and sediment and protect wetlands. Burns are patterned to enhance variety of wildlife habitat.

Mechanical Methods

Erosion and sediment are reduced by mandating slope limitations, contour tillage, buffers along streams ,and prompt revegetation. Treatments are timed to limit soil compaction. Roads, trails, and ditches are kept free of debris.

Herbicides

Herbicide and method, rate, and timing of application are selected to reduce risks to humans, wildlife, and other environmental elements. Supervision and training of applicators are mandatory to reduce risks of accidents and exposure. Protective clothing and safety equipment are mandated to reduce exposure. Drift of herbicides is reduced by using special spray nozzles and applying during favorable weather. Precautions are specified to reduce risks of spills and water or worker contamination. Water supplies and adjacent lands are protected by buffers.

Biological Method

Stocking and grazing patterns are controlled to reduce damage to soil, water, and native vegetation on grass balds.

Manual Method

Safety is provided through training and use of protective equipment and following hazard analyses for projects.

Environmental Consequences

Chapter IV presents detailed analyses of effects of vegetation management methods on various environmental elements. It also summarizes effects of alternatives on each element. Alternatives differ with respect to acres treated, mix of methods, and intensity of tools available in each method. Each of these factors influences the direction and severity of environmental effects. This section of the summary briefly discusses effects on key environmental elements.

Alternative A treats no acres. Alternative B treats minimum numbers of acres for basic resource protection. Alternatives C, D, Modified D, E, and Modified E employ all methods and use low- to moderate-disturbance tools. Alternatives F and G eliminate the use of herbicides and prescribed fire respectively. Alternatives C and H use high-disturbance tools such as severe slash burns, raking, and heavy disking. Alternative H treats the most acres and increases the use of high-disturbance tools.

Human Health and Safety

Accidental injuries from other methods pose greater risks to workers than health impacts from herbicides. Accidents are most common and severe with manual methods. Prescribed fire poses the next highest risk. Alternative A poses the lowest overall risk to human health and safety because no tools are used and risks are limited to wildfires.

Herbicides and additives evaluated and approved for use pose risks which are acceptable by EPA standards when required mitigation measures are followed. However, 2,4-D; 2,4-DP, and tebuthiuron pose risks to workers using backpack sprayers. And, 2,4-D poses risks to mixer-loaders. These risks are caused by the greater exposures for these workers, and can be mitigated to safe levels by changing chemicals, reducing application rates or exposure times, or by using waterproof clothing. In general, worker exposure is reduced by aerial application.

Wildlife

All herbicides and additives evaluated meet acceptable risk standards for terrestrial and aquatic wildlife (not listed as threatened, endangered or sensitive) when applied using typical rates. When applied at extreme rates, six chemicals pose risks to some species. Accidental spills of some chemicals into surface water would pose risks to some aquatic species.

Vegetation management benefits some wildlife species and harms others. For example, lack of treatment or low-disturbance tools favor mid- to late-successional habitats and associated wildlife; whereas early successional habitats and wildlife are favored by more intensive treatments. Alternatives C, D, Modified D, and E provide the greatest variety of habitats and associated wildlife, because they have the most balanced mix of low- to moderate-disturbance tools.

Threatened, Endangered, and Sensitive Species

Some species occur only in habitats where no vegetation management occurs. Low toxicities to animals, low risk of exposure and use of biological evaluations limit risks of adverse effects to listed animals. Since threatened, endangered, and sensitive plants may be extremely susceptible to herbicides, mitigation measures and biological evaluations are essential for protecting these plants.

Lack of treatments may prevent recovery of species which require periodic disturbance. Many species are fire-dependent, and some are sensitive to intensive or frequent treatments.

Vegetation

Lack of treatment or use of low-disturbance tools favors woody species. High disturbance favors herbaceous species. Alternative A most favors woody understory and midstory species.

Soil

Severe slash burns and raking pose high to extreme risks to soil productivity on all soils, mainly through loss of organic matter and nutrients. Moderate slash burns and piling pose low risks on some soils. Soil compaction is only significant for raking on clay and loam soils. Erosion is most severe after heavy disking.

Lack of underburns in alternatives A and G increase occurrence and adverse effects of wildfires. Alternative B best protects soil productivity because only low-disturbance tools are used and underburns prevent wildfire effects.

Water

No method significantly affects chemical water quality. Because herbicides are applied at low rates, are separated from streams and wells by buffers, and are subject to considerable downstream mixing and dilution, risks to water from typical application are very slight. Aerial herbicide application, however, increases risks of accidental pollution of streams.

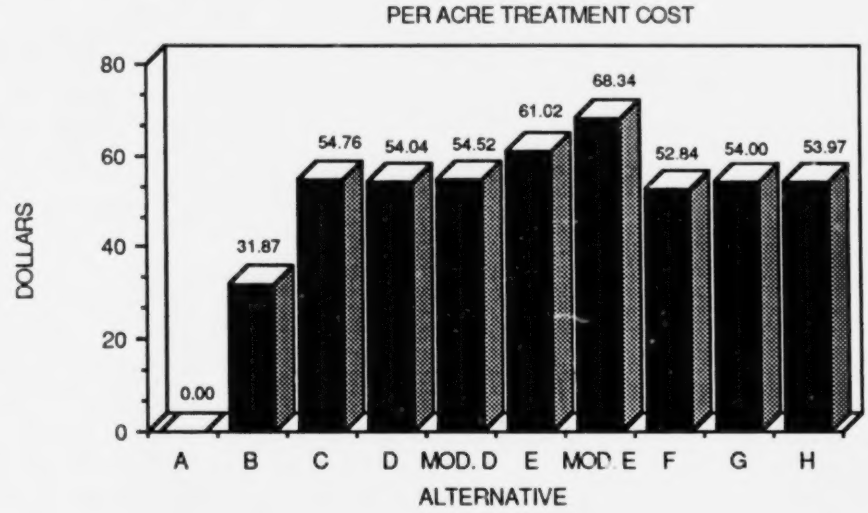
In general, stormflows and sediment loads are increased slightly by low to-moderate disturbance tools, and substantially by high-disturbance tools like severe slash burns, raking and heavy disking. Lack of underburns in alternatives A and G slightly increases occurrence of severe wildfires. Alternative A best protects water quality, but B does almost as well because only low-disturbance tools are used and underburns prevent some severe wildfire effects.

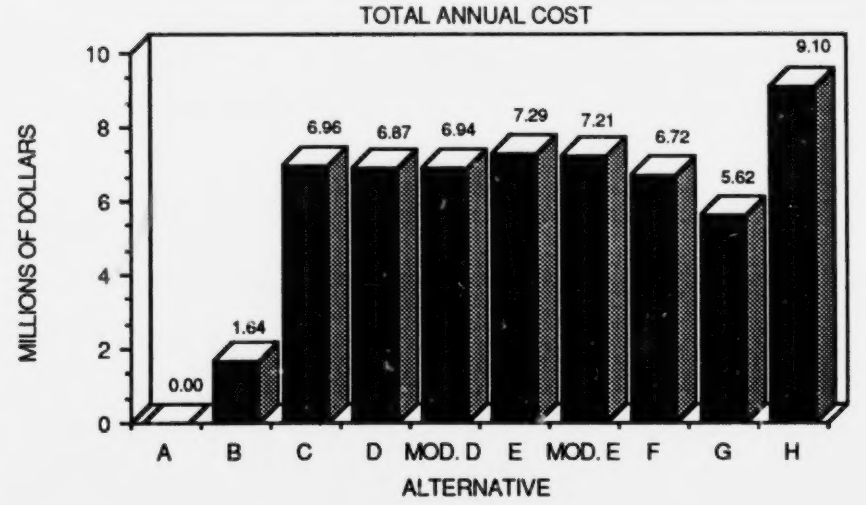
Air

Emissions of pollutant gases (carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, photochemical oxidants) are generally not sufficient to pose significant risks to air quality. Particulate emissions are least for grassy meadow and bald burns and pine-grass underburns, moderate for slash burns and pine-light brush underburns, and highest for wildfires. Long-term exclusion of underburns can cause available fuels to triple in some forest types, thus greatly increasing potential for wildfire incidence.

Economics

Direct, per acre costs are lowest for prescribed fire. Opportunity costs (sacrificed outputs) are generally reduced as market outputs increase. Lack of treatment reduces outputs and induces damages to facilities such as roads and recreation facilities which deteriorate from lack of maintenance. Alternatives C and D have the greatest advantage because their direct costs are among the lowest and their indirect costs are low to moderate. Alternatives A, B, and Modified E have high indirect costs.





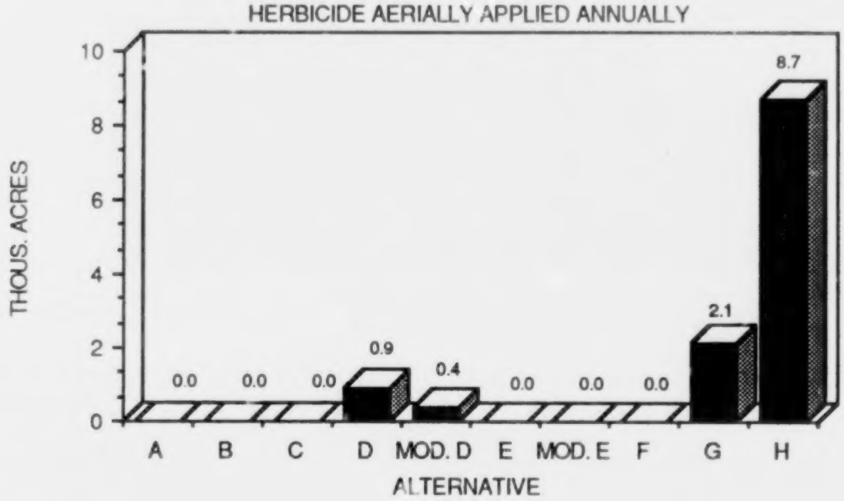
Social Values

Public response becomes negative at the extremes of no treatment or high-disturbance tools, and positive with manual methods. Visual values decline with high-disturbance tools, but vistas are lost if treatments are excluded. Cultural resources are most damaged by soil tilling tools like disking and raking. Alternatives Modified D, and E have the greatest advantage because vegetation management associated with Forest Land and Resource Managemen Plans that were developed through extensive public involvement can still be achieved with less risks to the environment, visual, and cultural resources.

Aerial Application

Three alternatives, D, Modified D, G, and H, include the use of aerial application of herbicides by helicopter. Alternative D treats 900 acres for utility right-of-ways (less than .02 percent of the study area), alternative Modified D treats 400 acres for utility right-of-ways (about .008 percent of the study area), alternative G treats 2,100 acres (about .04 percent of the study area), and alternative H treats 8,700 acres (less than .17 percent of the study area) for utility right-of-ways, site preparation, and timber stand improvement.

Mitigation measures for alternatives D, G, and Modified D are more restrictive than alternative H. Criteria for availability in Modified D is the most restrictive.



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CHAPTER I

Purpose and Need

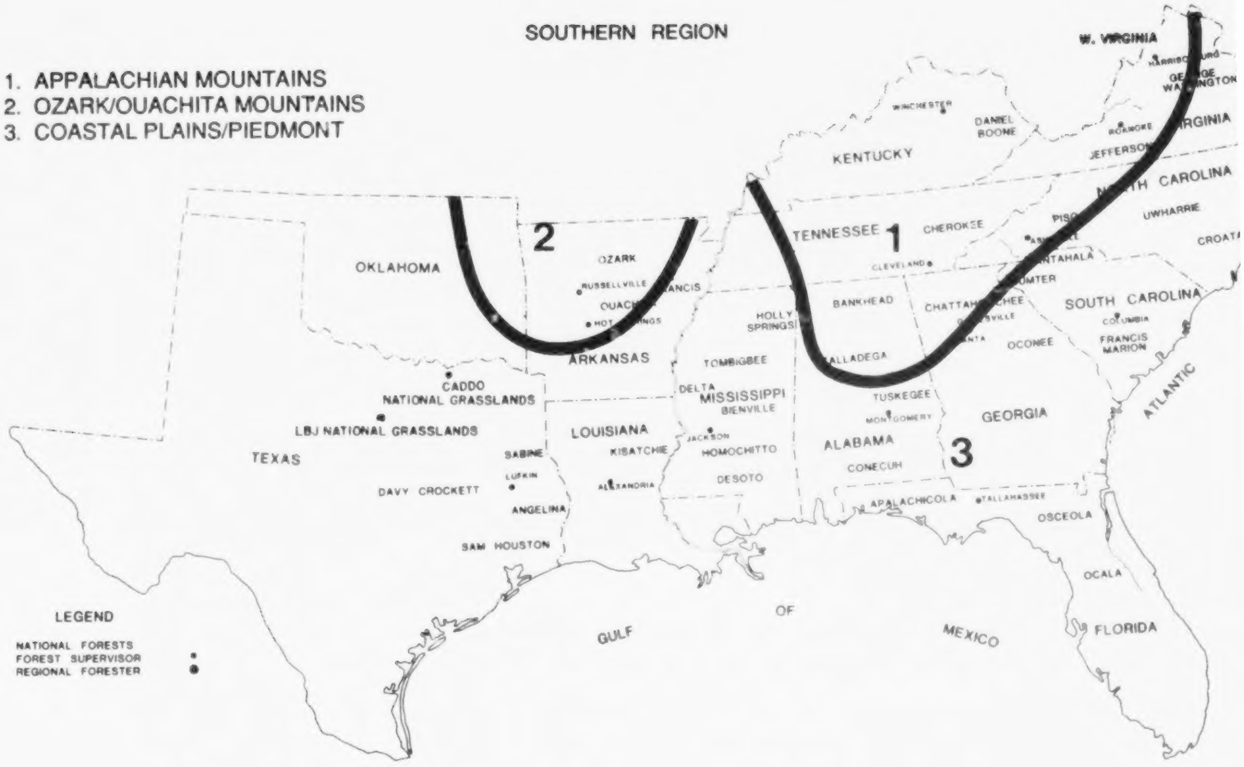

SOUTHERN REGION
1. APPALACHIAN MOUNTAINS
2. OZARK/OUACHITA MOUNTAINS
3. COASTAL PLAINS/PIEDMONT
1
2
3
W. VIRGINIA
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
OKLAHOMA
TEXAS
FLORIDA
WINCHESTER
DANIEL BOONE
JEFFERSON
CHEROKEE
CLEVELAND
BANKHEAD
TALLADEGA
TUSKEGEE
MONTGOMERY
CONECUH
APALACHICOLA
TALLAHASSEE
OSCEOLA
OCALA
OCONEE
COLUMBIA
FRANCIS MARION
UWHARRIE
CROATAN
NANTAHALA
SUMTER
OZARK
RUSSELLVILLE
OUACHITA
HOT SPRINGS
HOLLY SPRINGS
TOMBIGBEE
DELTA
BIENVILLE
JACKSON
HOMOCHITTO
DESOTO
KISATCHIE
ALEXANDRIA
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
SABINE
LUFKIN
DAVY CROCKETT
ANGELINA
SAM HOUSTON
GULF OF MEXICO
ATLANTIC
LEGEND
NATIONAL FORESTS
FOREST SUPERVISOR •
REGIONAL FORESTER ●

Figure I-1.--Area 1 is the Appalachian Mountains Area covered by this EIS.

Organization of this Document

This EIS follows the format recommended by the Council on Environmental Quality. Chapter I, Purpose and Need tells who, what, where, and why about the environmental analysis, and states the issues. Chapter II, Alternatives describes how alternatives were developed, explains which ones are considered, summarizes environmental effects, and identifies the preferred alternative. Chapter III, Affected Environment describes parts of the environment that would affect or be affected by the alternatives. This chapter does not describe effects (see chapter IV). Chapter IV, Environmental Consequences describes environmental impacts of alternatives, including the proposed action. Chapter V is a list of preparers and their experience and qualifications. Chapter VI shows consultations which were made and who received copies of the EIS. Chapter VII is a glossary of terms and acronyms. Chapter VIII lists reference materials. Chapter IX contains an index. Appendices contain specific information on topics too lengthy, technical, or detailed to be included in the text. Readers can quickly grasp important aspects of this EIS by reading the Summary beginning on page i in the preceding section.

Part of the EIS analysis includes a risk assessment, presented in appendix A. A summary of the risk assessment is available from USDA Forest Service, Southern Region, 1720 Peachtree Road, N.W., Atlanta, Georgia 30367.

CHAPTER I

PURPOSE AND NEED

IN BRIEF

Part A tells who prepared this environmental impact statement and what it is about. Part B tells why vegetation management is done. Parts C and D tell what decisions this document supports, how they relate to Forest Land and Resource Management Plans, and how they are implemented. Part E is an overview of the public involvement process. Part F contains a complete description of issues addressed. Part G describes some of the social aspects of herbicide use and briefly describes how and why the risk assessment was prepared.

A. INTRODUCTION

National Forests of the Southern Region are managed to provide a mix of goods and services to the public. Each Forest Land and Resources Management Plan details specific resource management objectives and output goals. These plans provide for access to the national forests, recreation, timber management, visual quality, water quality, balds management, and vegetation, wildlife and fish diversity. To produce these outputs some vegetation management must be done. Different environmental conditions and different objectives and goals determine the need for and amount of vegetation management done.

1. Area Analyzed

This Environmental Impact Statement (EIS) prepared by the USDA Forest Service Southern Region discloses environmental effects of vegetation management on national forests in the Appalachian Mountains physiographic area of the Southern Region (figure I-1 and table III-1). The EIS was guided by the National Environmental Policy Act of 1969 as amended, Council on Environmental Quality Regulations, and USDA Forest Service implementing procedures (FSM 1950).

2. Activities Addressed

The vegetation management program covered by this EIS contains seven major activities. They are:

- Site preparation for reforestation of pines and hardwoods; which is done to reduce plant competition so that pine and hardwood seedlings and saplings get needed amounts of sunlight, water, nutrients, and growing space in order to survive and grow in newly established stands.

- Stand management for timber stand improvement (release, precommercial thinning); which maintains balanced species composition and vigorous growth conditions for trees by controlling plant competition.

- Wildlife habitat improvement, including openings maintenance; which provides a wide variety of plants and habitat conditions beneficial to wildlife, and also protects and enhances habitats of threatened, endangered, proposed, and sensitive plant and animal species.

- Corridor maintenance for roads and trails, utilities, and railroads; which provides safe travelways and protects investments.

- Recreation site maintenance; which improves user safety and enjoyment at developed recreation sites.

- Mountaintop bald management; which preserves or enhances these unique features of the Appalachian Mountains.

- Fuels treatment; which is done to reduce hazardous fuels and risks of wildfire damage.

Activities affecting vegetation not addressed include silvicultural systems, harvest cutting methods, road construction, administrative site maintenance, range management, and management of nurseries, seed orchards, and aquatic vegetation.

3. Methods Evaluated

The EIS examines environmental effects of five vegetation management methods. These methods are:

- Herbicides, which can be applied as granules or liquid droplets by hand, machine, or helicopter.

- Mechanical, the use of machines such as mowers or tractors and bulldozers with attachments.

- Prescribed fire, which can be applied by ground and aerial ignition tools.

- Manual, the use of hand-held tools.

- Biological, the use of livestock to control vegetation by grazing.

B. NEED FOR ACTION

Vegetation management is the manipulation of plants to benefit a variety of forest resources and investments. It is needed to protect and improve forest health and wildlife habitat. It is required to maintain facilities such as roads, trails, utility lines, and recreation areas. It is essential to meet the special needs of mountaintop balds and some threatened, endangered, proposed, and sensitive species. Forest Land and Resource Management Plans call for many vegetation management activities. This EIS discloses environmental effects of those activities.

1. Strategies for Vegetation Management

A characteristic of vegtation management is the control of plant growth. Growth of some plants is undesirable if they compete vigorously with desired plants for sunlight, water, nutrients, and growing space. Growth of other plants may pose a fire hazard in some forest sites or a safety hazard in corridors and recreation sites.

All vegetation is part of an ecological system. A plant species may be desired on most sites but not others. For example, thickets of rhododendron and mountain laurel may be wanted on a heath bald but may crowd out young trees in a forest stand. Snags create wildlife perching and nesting sites in the general forest but pose a safety hazard in campgrounds. The need for vegetation management depends on objectives for each site.

On national forests, just enough treatment is usually done to meet minimum vegetation management needs. For example, pine stands are managed to include a hardwood component of up to 30 percent. Utility lines and roadsides may be managed for a variety of low-growing plants. Four strategies are available to meet the vegetation management needs of any given site:

Prevention, treating before damage occurs. Prevention activities usually intervene once in natural plant growth and succession to give desirable plants a temporary growth advantage over undesirable ones. Examples are site preparation and timber stand improvement.

Maintenance, treating in planned cycles. Maintenance activities intervene frequently in natural plant growth and succession to perpetuate a given state. Examples are fuels treatment, wildlife habitat improvement, and maintenance of corridors, recreation sites, and mountaintop balds.

Correction, treating after damage occurs. Correction activities may be needed if prevention or maintenance was not done or not effective. Examples are restoring overgrown balds or failed regeneration areas.

No action, no treatment. Natural processes are allowed to progress without human intervention. No action is an option in most activities. For example, some sites do not require site preparation or timber stand improvement to achieve adequate stocking of desired tree species.

2. Treatments and Their Effectiveness

Effectiveness is measured by how well one treatment achieves the desired plant control results. It varies with choice of method and tool and type and timing of treatment.

Effectiveness of competition control with manual and light mechanical methods (mowing, chopping, shearing, ripping, scarifying) is typically low because regrowth of herbaceous plants and resprouting of woody plants is usually immediate and vigorous. Raking and disking are more effective in reducing competing woody plants since they affect their root systems, but they also may severely impact resources such as soil and water.

Effectiveness of prescribed fire and biological methods varies with intensity of burning or grazing. Herbicides are highly flexible because choice of herbicide and method, rate, and timing of treatment can be varied to affect different plants in different ways.

Broadcast treatments cover an entire area and affect many plants. Selective treatments affect only a few individual plants in an area. Manual treatments are mostly selective. Prescribed fire, mechanical, and biological methods are mostly broadcast treatments. Herbicides may be applied by selective or broadcast means.

Timing of treatment can modify a tool's effectiveness. For example, an intense dormant season fire eliminates few woody plants from a site if they are vigorous sprouters. However, a light to moderate growing season burn may eliminate many of the same plants by occurring after they have used up the season's root reserves and so cannot resprout as vigorously.

3. Objectives and Treatments for Vegetation Management

This EIS covers the seven vegetation management activities listed on page I-2. Each activity has a unique set of objectives; together with site conditions, these objectives determine the type and degree of plant control desired and the strategy and treatments that are most appropriate.

Fuels Treatment

Fuels are reduced in some yellow pine and pine-hardwood stands to keep them from building up to hazardous levels. Fuels are treated about once every 6 years in the Appalachian Mountains. Prescribed fire is the only effective method, since it consumes fuels while other methods merely redistribute them.

Wildlife Habitat Improvement

This activity includes maintenance of wildlife openings, as well as understory treatments in the general forest to enhance habitat variety and protect habitats of threatened, endangered, proposed, and sensitive species.

Wildlife openings are maintained to perpetuate open areas rich in herbaceous and shrubby food plants. Mowing may be done more than once a year. Herbicides, prescribed fire, and manual methods may also be used to reduce or kill encroaching shrubs and vines. Many openings are periodically disked and replanted to rejuvenate their cover.

Understory treatments may be done every 3 to 4 years to open up the understory and spur the growth of woody and herbaceous food plants. Prescribed fire is an excellent broadcast method for producing these results. Manual and selective herbicide treatments are used to remove individual midstory trees; herbicides generally eliminate the resprouting that commonly follows use of manual methods.

Corridor Maintenance

This activity includes maintenance of trails, roadsides, and utility (mostly power and gas) lines. Prescribed fire is almost never used due to risks to resources, investments, and forest visitors.

Trailside vegetation is treated each year to keep the trail open and maintain vistas. Nearly all work is done by manual methods. Herbicides are used to control some noxious or fast-growing plants, and some grassy trail heads and overlooks are mowed.

Roadsides are treated to maintain low-growing plants for safe sight distances and faster drying by sunlight. Mowing is used most, but herbicides are also used to reduce prolific woody growth and favor grasses and flowering plants. Manual methods are often used at sensitive sites such as stream crossings. A segment of Forest Service road is usually treated once every 3 years, but county/State roads may be treated annually.

Utility lines are treated to maintain low-growing plants that will not interfere with operation. Treatments occur about every 6 years in power lines for a low brush and herbaceous cover and every 2 years in gas lines for a continuous herbaceous cover. Mowing is favored on gentle terrain and herbicides are favored elsewhere. Manual methods are used least since they often promote vigorous resprouting of woody plants.

Recreation Site Maintenance

Mowing is used to maintain short herbaceous cover in picnic, camping, and other use areas. Manual methods are used to remove hazard trees and trim encroaching woody plants. Selective herbicide treatments are used to kill noxious weeds and eliminate encroaching plants around certain facilities.

Mountaintop Bald Management

Balds are treated to maintain their grass or heath cover. Many large, fenced grass balds are maintained by annual livestock grazing. Prescribed fire is periodically used to stimulate regrowth of grasses and legumes. Mowing is used on some gentle, accessible grass balds. Manual and selective herbicide treatments are used to control encroaching trees, shrubs, and vines. Only a few heath balds are being treated, mostly with prescribed fire and manual tools.

Site Preparation

Site preparation is done near the start of each rotation to give desired seedlings enough light, water, nutrients, and space to become firmly established. It is done to enhance natural or artificial regeneration in evenage or unevenage management. It usually follows clearcut or seedtree harvest but often precedes shelterwood or selection harvest

Herbicides and prescribed fire are used most for pine site preparation. Herbicides are very effective in providing precise competition control. Manual or mechanical methods followed by prescribed fire can retard hardwood sprouting if timed to help exhaust root reserves. Herbicides followed by prescribed fire ("brown and burn") are some times used to control intense competition on productive sites. Manual methods alone may be ineffective due to resprouting, and mechanical methods are restricted to gentle terrain.

Manual methods and pre-harvest herbicide treatments are used almost exclusively for hardwood site preparation. Prescribed fire is rarely used, and mechanical methods are never used. Manual methods are used most, but selective herbicide treatments can reduce understory competition before harvest to give some desirable species a better chance to become established.

Timber Stand Improvement

This activity includes release, precommercial thinning, and understory species control. Release occurs in a stand's first few years, precommercial thinning after the first few years, and understory species control usually after crown closure. Their objective is to give desirable trees a growth advantage over competing trees.

Nearly all timber stand improvement occurs as release. Only herbicides and manual methods are used; herbicides are much more effective in controlling resprouting. Precommercial thinning is done with manual tools, although some can be done with mechanical tools. Understory species control is done mostly with prescribed fire to top-kill competing trees; use of manual and selective herbicide treatments to remove individual midstory trees is limited.

4. Harvest Systems and Vegetation Management

Each Forest Land and Resource Management Plan discusses which silvicultural system and associated harvest cutting methods are appropriate, and where they will be used, based on each forest's unique mixture of forest and public needs. However, in order to facilitate a better understanding of their relationships to vegetation management, below is a brief discussion of the biological requirements and rationale of why different type species require different silvicultural and harvest systems.

Timber harvest systems and vegetation management mustconform to the biological needs of the desired tree species. Tree species are grouped into 3 classes based on their ability to reproduce and grow despite shading and root competition from other species:

Intolerant species require much light and do not tolerate strong root competition as young trees. They have high rates of photosynthesis, respiration, and growth. They include the pines and such hardwoods as yellow poplar and black cherry.

Intermediate species require moderate light and/or good competition control as young trees. They therefore need careful treatment to successfully regenerate and develop into quality timber. They include many of the oaks and hickories.

Tolerant species do well in (and may require) little light and tolerate root competition as young trees, and usually respond well to release. They have relatively low rates of photosynthesis, respiration, and growth. They include spruces, firs, hemlocks, beeches, and most maples.

Evenage systems include clearcut, seedtree, and shelterwood harvests. Unevenage systems include single-tree and group selection harvests. Clearcut and seedtree harvests create open conditions with abundant light. Shelterwood and group selection harvest can be varied to create low to abundant light. Single-tree selection harvests usually create low to moderate light.

Intolerant species are regenerated by harvest systems that create open conditions with abundant light. However, these conditions also favor pioneer species such as dogwood, black locust, and red maple which reproduce and grow profusely. Even after effective site preparation, release is usually needed to prevent these species from overtopping and killing desired trees. Herbicides are often used to prevent pioneer species from resprouting and overtaking the desired trees.

Intermediate species are regenerated by harvest systems that create moderate to abundant light. Care is needed to create and maintain just the right amount of light and space to give these slower-growing species an edge over more tolerant and intolerant trees. Pre-harvest site preparation with fire and selective herbicide treatments is often used to prepare the seedbed and aid early growth. Post-harvest release with selective herbicide treatments is often used to control the amount of light and space around desired trees and keep them from being crowded out or overtopped.

Tolerant trees can be regenerate by almost any harvest system. They will be overtopped by pioneer species in open stands with much light, but will outlive these trees and eventually take their place in the overstory. They will survive for years under closed stands with little light and will usually respond well to release.

C. SCOPE OF DECISIONS

This EIS is used to make decisions about how the vegetation management program on national forests in the Appalachians is conducted. Major decisions are: (1) what methods and tools are allowed; (2) what intensity and frequency of treatments are used; and (3) what management requirements and mitigation measures are applied. The EIS provides analytical data that may be used when making site-specific decisions in the future.

D. IMPLEMENTING THE DECISION

Decisions based on this EIS are implemented in concert with Forest Land and Resource Management Plans. Plans set overall direction for managing national forests. The selected alternative from this EIS sets further direction on how vegetation is managed. Depending on which alternative is selected, Plans may need to be amended, especially regarding methods and tools allowed and mitigation measures (standards and guides) applied. Amendments to Plans will be done through the Record of Decision which follows this EIS.

Site-specific vegetation management projects must be done within constraints set by the Plans and this EIS. Together, these two documents define the limits within which such projects may operate. Key components of project implementation include site analysis, project design, and monitoring.

1. Site Analysis

Vegetation management projects must receive site-specific environmental analysis in compliance with the National Environmental Policy Act (NEPA). Data on sites eligible for treatment are gathered and evaluated by trained personnel familiar with local environmental conditions and relationships. A detailed analysis of site conditions and environmental effects of alternative treatments is done. Information from this EIS and those done for Plans is used when applicable and valid. NEPA procedures ensure that information is available to public officals and citizens before decisions are made or actions are taken.

The analysis must evaluate direct, indirect, and cumulative environmental effects of vegetation management, considering the unique physical and biological characteristics of the site. It must evaluate a reasonable range of alternatives, including a "no action" alternative, which vary the mix of methods and intensity of tools used within the constraints set by this EIS and the Plans.

Effects to be evaluated include long-term soil productivity; water, air, and visual quality; vegetation; wildlife; fish; cultural resources; and effectiveness of treatments. A biological evaluation of potential effects on threatened, endangered, proposed, and sensitive species is also done.

2. Project Design

Good design requires a thorough analysis. Project design depends on effectiveness of treatments in meeting project objectives and on environmental effects they cause. Equally important are the constraints set by the alternative selected in the Record of Decision which follows this EIS. This alternative defines methods and tools that are allowed, intensity and frequency of treatments that must be used, and minimum mitigation measures that must be applied. Managers must work within these constraints to decide which vegetation management methods are best suited to the specific site conditions. Projects that are structured and timed to meet vegetation management objectives well and to pose minimal environmental risks are usually favored.

3. Monitoring

Monitoring of environmental effects is done during and after treatment to assure that the project is implemented as designed and that mitigation measures are effective. Information gathered may be used to validate or refine treatments or to add further mitigation measures. A full array of treatments in diverse environmental conditions is monitored. Minor projects and those whose effects are already well documented may not be monitored.

Effects of treatments on vegetation, soil, wildlife, and threatened or endangered species are monitored in the treated area. Effects on water and aquatic life may be monitored onsite and downstream. Effects on air quality may be monitored onsite and downwind.

Monitoring during treatment is important if changes in tools or intensity are needed. Most monitoring is done just after treatment and at appropriate intervals thereafter. Monitoring is seldom necessary beyond 3 years after project completion.

E. PUBLIC INVOLVEMENT

A public involvement summary is in chapter VI. The Notice of Intent to prepare this EIS was published in the September 11, 1986 Federal Register. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987, Federal Register. This revision described methods which would be evaluated and estimated dates of availability of draft statements and final statements.

In June 1987 more than 13,000 interested individuals, groups, and agencies were asked to identify issues to be addressed in this EIS. Concurrently, a press release was distributed Regionwide. About 40 key contacts were also reached by phone or in person. Between June 1987 and March 1988, replies were received from 654 respondents. Analysis of this public response identified 5 issues to be addressed. Also, in March 1988, 5,000 information tabloids about issues and alternatives were distributed.

F. ISSUES ADDRESSED

An issue is a subject or question of widespread public interest relating to management of a national forest. The following issues incorporate concerns expressed by the public, employees, and managers in the 654 responses we received by March 1988.

1. Balance of Resources

Some commenters questioned the need for any vegetation management. They felt that a "hands-off" approach would be best and that any method used would upset the "balance of nature." Concern was expressed that the Forest Service uses vegetation management for the benefit of timber, and some wanted vegetation management only for wildlife and fish, recreation, aesthetics, special areas (balds, botanical areas), or threatened and endangered species. Others requested that grapevine control be minimized so as to enhance soft-mast production. Overall, manual methods were viewed as being easier on the land and as providing greater employment opportunities. The order of preference for methods to be used was manual, mechanical, prescribed fire, and herbicides.

2. Inadequate Communication--Lack of Understanding

Many respondents supported the technical ability of the Forest Service to select the "best" tools to do the job. Communication about management practices, however, was perceived as an obstacle. In addition, there was often a lack of understanding about objectives for managing vegetation, and a sense that public input is often ignored. Several commenters only wanted a response to their questions and concerns so they would have better-informed opinions. In fact, some felt they could readily support agency programs if they knew more about project goals and objectives and about environmental analysis processes. They want the Forest Service to explain the when, why, and where of treatments. Many people see the EIS as an opportunity to advance our knowledge about all vegetation manangement practices on national forests.

3. Known and Unknown Effects of Herbicides

Herbicide use is the most controversial method for managing vegetation. Many people voiced concerns about potential short- and long-term adverse effects on water quality, wildlife and fish, and human health and safety. Other concerns included animal and plant diversity, threatened or endangered plants and animals, soil productivity, visual quality, and air quality. Although some people are suspicious of herbicides because of limited information on long-term effects, others support herbicide treatments because of their effectiveness and low cost. If herbicides are used, people want them to be applied by qualified Forest Service personnel, and they want effects of herbicides to be studied.

Generally, the most favored way to apply herbicides is to treat each plant individually. People are concerned that aerial or mechanical broadcast applications might allow drift into areas not being treated and may eliminate hardwoods or threatened and endangered plants. Some people however, support aerial application of herbicides, especially for managing vegetation along utility corridors.

4. Fire Effects in Mountain Environments

The public generally accepted prescribed fire as a management tool. Many respondents felt prescribed fire was beneficial to wildlife, provided for diversity of plants and animals, and was cost-effective. Major concerns were smoke management, including coordination with other land managers; and potential adverse effects on air quality, soil productivity, and water quality. Other people expressed concerns about potential effects on threatened and endangered species, aesthetics, and human health and safety. Many were also concerned about prescribed fire in hardwood stands, especially possible adverse effects of intense growing season burns.

5. Effects from Mechanical Treatments

Though not knowledgeable about mechanical methods of vegetation management, commenters generally supported them. Mechanical methods were thought to create employment opportunities and have fewer adverse effects than herbicides or prescribed fire. Most concerns were about potential economic, water quality and fisheries, soil productivity, and aesthetic effects. While some people favored mechanical maintenance of roads and utility corridors (rights-of-way), most felt it created higher safety risks and negatively affected diversity within the right-of-way.

6. Unrelated Comments

Several comments were received on a wide range of topics beyond the scope of this EIS. These comments, though meaningful, are not included as issues. Some categories of comments which won't be addressed are silvicultural systems, harvest cutting methods, off-road vehicles, littering, road construction, wilderness designation, forest signs, landscape-wide diversity, illegal activities, acid rain, insect control, or multiple-use in a general landscape-wide sense.

Most of these unrelated comments have been analyzed and addressed in Forest Land and Resource Management Plans. For example, each plan discusses which silvicultural system and associated harvest cutting methods are appropriate, and where they are to be used, based on each forest's unique mixture of resources and public needs. This EIS does not reanalyze those issues, but does evaluate vegetation management methods for the activities listed in section A of this chapter.

G. ABOUT HERBICIDES

This EIS analyzes five methods of vegetation management, but herbicide use is a focal point of controversy. Issues about herbicides are both scientific and emotional. The public seems to distrust forest managers who use herbicides. The respondents to our inquiry expressed fear of adverse health effects, including cancer. And, indeed, there is some scientific uncertainty about long-term effects of many herbicides. People commonly ask questions like, "Do these herbicides cause cancer or birth defects?" "What are the short-term and long-term effects of exposure to herbicides?" and "How do they affect wildlife and other aspects of the environment?"

These questions are discussed in the risk assessment in appendix A. It documents an exhaustive study of the most up-to-date data on herbicides (and materials mixed with them for application) proposed for use in the Southern Region. This risk assessment presents information on each herbicide's toxicity, evaluates potential exposure of humans or animals to the herbicides, and then estimates the risk of harmful effects for those toxicities and exposures.

The estimates of risk take into account scientific uncertainty and account for differences in individual sensitivities by incorporating safety factors. The risk assessment discloses the modeling process used to estimate risk. Discussion of herbicide effects in chapter IV and mitigation measures for herbicides in chapter II are based on the scientific findings of the risk assessment.

Alternatives

CHAPTER II

CHAPTER II

ALTERNATIVES

IN BRIEF

Part A discusses how alternatives were developed. Part B describes each alternative, including methods and tools available, average treatment frequencies, and estimated acres treated. Part C lists alternatives considered but eliminated from detailed study. Part D defines each method and tool and explains how they are used. Part E describes how resources are managed and what actions are taken to lessen adverse impacts or to enhance beneficial effects. Parts F through H compare how the alternatives respond to issues and affect the environment.

A. ALTERNATIVE DEVELOPMENT PROCESS

Several alternatives were developed to respond to issues (Chapter I) and cover a broad range of possible mixes of vegetation management methods. Issues were based on public comments received in 1987-88 and on management concerns, and were shared with the public in March 1988. In May 1988, an interdisciplinary team considered additional public comment and developed alternatives to respond to the issues.

Each alternative conforms to the following guidelines:

1. Considers the goals, objectives, and decisions of Forest Land and Resource Management Plans;

2. Should not be constrained by funding;

3. Responds to issues (Chapter I);

4. Should be implementable by the Forest Service;

5. Conforms to Federal laws and regulations (unless the alternative contemplates a specific change in laws or regulations).

B. ALTERNATIVES CONSIDERED IN DETAIL

This section describes the amount and nature of vegetation management done in each alternative. First, the underlying theme of the alternative is stated. Second, the methods and tools allowed in the alternative are described. Third, based on field data, the average frequency of activities that recur every few years (fuel reduction, wildlife habitat improvements, corridor maintenance) is presented. Frequencies are not shown for site preparation and timber stand improvement because they usually occur once per stand rotation, not on established cycles. Finally, average number of acres treated per year by each method are estimated. These acres are only projections used to evaluate environmental effects quantitatively. They were derived by professionals familiar with vegetation management activities and environmental conditions in the field. They are displayed for all national forest lands in the area, not for individual units. Upon implementation, the actual program may vary from these projections.

1. Alternative A (No Action)

Theme

In this "no action" alternative, vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Methods and Tools

No treatments of any kind are allowed.

Avg Frequency (yrs)

None.

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	0	0
Herbicides	0	0
Manual	0	0
Mechanical	0	0
Biological	0	0
	0	0

2. Alternative B

Theme

Vegetation management is restricted to treatments that achieve minimum resource objectives. This alternative was developed to respond to those who want less vegetation management done with less environmental disturbance than at present.

Number of acres treated and intensity and frequency of treatments are reduced from present levels to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 1.0 percent of national forest land in the Appalachians.

Hazardous fuel treatment occurs in arson-prone areas when fuel buildup threatens facilities and dwellings. Wildlife treatments occur to promote recovery of threatened and endangered (T&E) species and when habitat conditions seriously limit populations. Corridors are maintained when vegetation threatens safety or investments on trails, roads, and utility lines. Site preparation and timber stand improvement are done only if needed to achieve minimum stocking. Mountaintop balds are maintained only to protect their ecosystems, T&E habitat, and public use. Recreation site maintenance is limited to hazard removal.

Substantial shifts from present mix of methods occur in pine release (from use of herbicides to manual methods), bald maintenance (from use of prescribed fire to livestock grazing), and wildlife habitat improvement (from use of mechanical methods to prescribed fire).

Added mitigation measures beyond those presently required are applied. All those listed in section II.E apply except 1.b.(7,9), 2.b.(6,7), and 2.c.(18,26).

Methods and Tools

Prescribed Fire: Only low intensity burns with timing and location restricted are applied by ground and aerial ignition tools. Major uses are wildlife habitat improvement, hazardous fuel reduction, and pine site preparation.

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) only. Major uses are pine and hardwood site preparation, roadside maintenance, and pine release. Selective treatments only are allowed in hardwood site preparation and maintenance of trails, recreation areas, and balds. Broadcast treatments are allowed only in pine site preparation and release and maintenance of roadsides and utility lines, and then only when site conditions require broadcast treatments.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are hardwood site preparation, pine release, and roadside and trail maintenance.

Mechanical: Only low disturbance tools (mowing, chopping, shearing, ripping, scarifying) are allowed. Major uses are roadside maintenance, recreation area maintenance, and wildlife habitat improvement.

Biological: Light to moderate livestock grazing is used for vegetation management only on large, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Railroads; Balds (grazed)	1
County/State roads; Recreation sites	2
T&E habitat; Trails; Gas lines	3
Other wildlife habitat; FS roads; Balds (other)	4
Hazardous fuels; Power lines	7

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	22,425	41.7
Herbicides	6,005	11.2
Manual	11,034	20.5
Mechanical	12,184	22.6
Biological	2,128	4.0
	53,776	100.0

Alternative B

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	6,005	12,184	22,425	11,034	2,128
Fuels treatment	0	0	9,872	0	0
T&E species habitat	0	0	2,883	202	0
Other wildlife habitat	0	1,784	7,724	83	0
Balds habitat	27	131	559	71	2,128
Trails	25	64	0	1,192	0
Recreation sites	298	2,087	0	596	0
Roads-Forest Service	891	6,414	0	1,605	0
Roads-Co/State	775	1,008	0	156	0
Power lines	576	288	0	97	0
Railroads	25	7	0	0	0
Gas lines	16	119	0	30	0
Site prep.-Pine	1,394	282	1,371	735	0
Site prep.-Hardwood	769	0	16	4,455	0
TSI-Pine*	1,209	0	0	1,812	0
TSI-Hardwood*	0	0	0	0	0

*--Timber stand improvement - Includes release, precommercial thinning, and understory species treatments.

HIKER TRAIL

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Balds habitat	100	0
Trails; Recreation sites	100	0
Roads-Forest Service	30	70
Roads-Co/State; Railroads	10	90
Utility (power/gas) lines	40	60
Site prep./TSI-Pine	90	10
Site prep.-Hardwood	100	0

3. Alternative C

Theme

The mix of methods, number of acres treated, and intensity and frequency of treatments presently specified in Forest Land and Resource Management Plans are applied. Acres treated per year total 2.5 percent of national forest land in the Appalachians.

Hazardous fuels are treated only by prescribed fire. Wildlife habitat improvement is done almost totally by prescribed fire and mechanical methods. Corridors and recreation areas are maintained mostly by mechanical and manual methods. Balds are maintained mostly by livestock grazing and prescribed fire. Site preparation is done mostly by herbicides and prescribed fire for pine, and almost totally by manual methods and herbicides for hardwood. Timber stand improvement is done almost totally by herbicides and manual methods.

Only those mitigation measures presently required are applied. All those listed in section II.E apply except 1.h.(22,24), 2.a.(7,8,9), and 2.c.(3,4,5,6,13,14,17,18,19,26).

Methods and Tools

Prescribed Fire: Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and pine site preparation.

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer) and machine (boom sprayer, granular spreader). Major uses are pine and hardwood timber stand improvement, pine and hardwood site preparation, and roadside maintenance.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are hardwood site preparation, pine and hardwood timber stand improvement, and trail maintenance.

Mechanical: Low to high disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, disking, raking) are allowed. Major uses are roadside maintenance, wildlife habitat improvement, and recreation area maintenance.

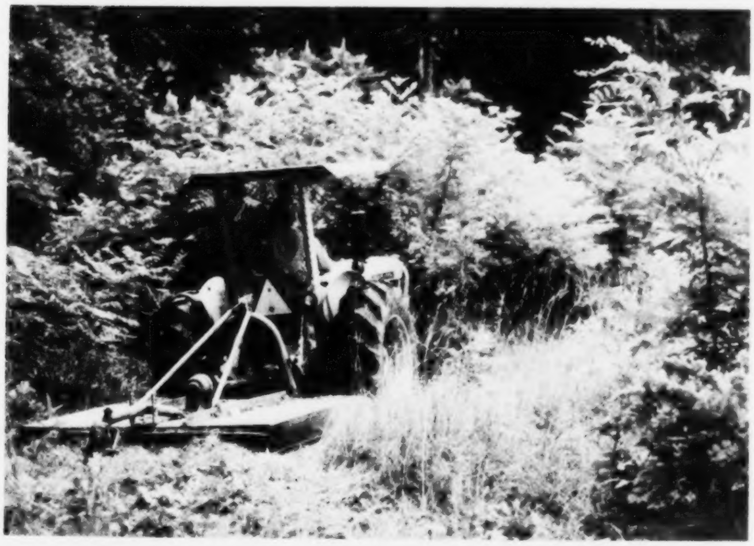
Biological: Light to moderate livestock grazing is used for vegetation management only large, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
Gas lines	2
T&E habitat; FS roads; Balds (other)	3
Other wildlife habitat	4
Hazardous fuels; Power lines	6

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	44,807	34.5
Herbicides	24,494	18.8
Manual	33,048	25.4
Mechanical	24,859	19.1
Biological	2,837	2.2
	130,045	100.0



Alternative C

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	24,494	24,859	44,807	33,048	2,837
Fuels treatment	0	0	23,033	0	0
T&E species habitat	0	0	2,883	202	0
Other wildlife habitat	87	8,039	11,969	119	0
Balds habitat	48	233	994	127	2,837
Trails	77	192	0	3,578	0
Recreation sites	596	4,172	0	1,192	0
Roads-Forest Service	1,188	8,554	0	2,139	0
Roads-Co/State	1,552	2,018	0	310	0
Power lines	673	337	0	112	0
Railroads	24	8	0	0	0
Gas lines	25	178	0	44	0
Site prep.-Pine	5,573	1,128	5,487	2,939	0
Site prep.-Hardwood	3,073	0	63	17,818	0
TSI-Pine*	10,150	0	378	2,423	0
TSI-Hardwood*	1,428	0	0	2,045	0

*--Timber stand improvement - Includes release, precommercial thinning, and understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Wildlife habitat; Balds habitat	100	0
Trails; Recreation sites	100	0
Roads-Forest Service	20	80
Roads-Co/State; Railroads	10	90
Utility (power/gas) lines	30	70
Site prep./TSI-Pine	80	20
Site prep./TSI-Hardwood	100	0

4. Alternative D

Theme	Use of prescribed fire and herbicides increases from the present, and use of manual and mechanical methods declines. This alternative was developed to analyze a full range of methods and tools that would provide more effective plant control with less environmental disturbance than at present.

Number of acres and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 2.5 percent of national forest land in the Appalachians.

The largest shifts among methods occur in site preparation (from use of manual methods to herbicides and prescribed fire), roadside maintenance (from use of mechanical and manual methods to herbicides), and wildlife habitat improvement (from use of mechanical methods to herbicides).

Aerial application of herbicides is introduced on selected utility lines.

Added mitigation measures beyond those presently required are applied. All those listed in section II.E apply.

Methods and Tools

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and pine site preparation.

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader) and helicopter (granular and liquid systems). Major uses are pine and hardwood timber stand improvement, pine and hardwood site preparation, and maintenance of roadsides and utility lines. Selective treatments only are allowed in hardwood site preparation and release and maintenance of wildlife habitat, trails, balds, and recreation areas. Broadcast treatments are allowed only in pine site preparation and release and maintenance of roadsides and utility lines, and then only when site conditions require broadcast treatments. Aerial application is used only on utility lines where rugged terrain makes use of other methods impractical (900 acres projected per year).

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are hardwood site preparation, trail maintenance, and pine and hardwood timber stand improvement.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance, wildlife habitat improvement, and recreation area maintenance.

Biological: Light to moderate livestock grazing is used for vegetation management only on large, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
Gas lines	2
T&E habitat; FS roads; Balds (other)	3
Other wildlife habitat	4
Hazardous fuels; Power lines	6

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	46,553	35.8
Herbicides	34,149	26.3
Manual	26,937	20.7
Mechanical	19,569	15.0
Biological	2,837	2.2
	130,045	100.0

Alternative D

Projected acres/year by method by program:

	Method					
Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	33,249	900	19,569	46,553	26,937	2,837
Fuels treatment	0	0	0	23,033	0	0
T&E species habitat	75	0	0	2,958	52	0
Other wildlife habitat	1,776	0	6,339	12,069	30	0
Balds habitat	127	0	233	994	48	2,837
Trails	177	0	92	0	3,578	0
Recreation sites	1,096	0	3,772	0	1,092	0
Roads-Forest Service	4,188	0	6,554	0	1,139	0
Roads-Co/State	2,052	0	1,518	0	310	0
Power lines	73	800	237	0	12	0
Railroads	25	0	7	0	0	0
Gas lines	36	100	89	0	22	0
Site prep.-Pine	6,473	0	728	6,487	1,439	0
Site prep.-Hardwood	4,573	0	0	563	15,818	0
TSI-Pine*	10,650	0	0	449	1,852	0
TSI-Hardwood*	1,928	0	0	0	1,545	0

*--Timber stand improvement includes release, precommercial thinning, and understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

	Ground Applications		Aerial Application	
Program	% Selective	% Broadcast	% Selective	% Broadcast
Wildlife (incl. T&E) habitat	100	0	0	0
Balds habitat	100	0	0	0
Trails; Recreation sites	100	0	0	0
Roads-Forest Service	30	70	0	0
Roads-Co/State; Railroads	10	90	0	0
Utility (Power/gas) lines	40	60	0	100
Site prep./TSI-Pine	80	20	0	0
Site prep./TSI-Hardwood	100	0	0	0

5. Alternative MODIFIED D

This alternative was developed in response to many comments about the Draft EIS expressing concerns about potential exposure of people, animals, and plants to herbicides in alternative D. It is a modification of alternative D. Its major changes from alternative D are a reduction in total herbicide use and aerial herbicide application, an increase in use of mechanical and manual methods, and an increase in the percentage of herbicides applied by selective treatment

This alternative is exactly like alternative D in projected acres and frequencies of treatment, methods and tools available, and mitigation measures required. Therefore, it actions and effects fall within the range of those of the alternatives analyzed in the Draft EIS.

Nearly all the reduction in herbicide use from alternative occurs in roadside maintenance (to use of mechanical and manual methods), wildlife openings (to use of mechanical methods and prescribed fire), and recreation site maintenance (to use of mechanical methods). Nearly all of the increase in mechanical methods occurs as mowing. Changes occur to lessen real or perceived exposure of people, animals, and plants to herbicides, but herbicide us is still higher than at present in these activities to improve specific plant control results.

Aerial herbicide application is limited to major utility transmission lines in rugged, remote, and uninhabited terrain where use of other methods is not practical.

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	46,753	35.9
Herbicides	29,335	22.6
Manual	27,899	21.4
Mechanical	23,221	17.9
Biological	2,837	2.2
	130,045	100.0

Alternative MODIFIED D

Projected acres/year by method by program:

	Method					
Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	28,935	400	23,221	46,753	27,899	2,837
Fuels treatment	0	0	0	23,033	0	0
T&E species habitat	75	0	0	2,958	52	0
Other wildlife habitat	476	0	7,439	12,269	30	0
Balds habitat	127	0	233	994	48	2,837
Trails	100	0	92	0	3,655	0
Recreation sites	796	0	4,072	0	1,092	0
Roads-Forest Service	1,584	0	8,290	0	2,007	0
Roads-Co/State	1,552	0	2,018	0	310	0
Power lines	440	400	253	0	29	0
Railroads	25	0	7	0	0	0
Gas lines	136	0	89	0	22	0
Site prep.-Pine	6,473	0	728	6,487	1,439	0
Site prep.-Hardwood	4,573	0	0	563	15,818	0
TSI-Pine*	10,650	0	0	449	1,852	0
TSI-Hardwood*	1,928	0	0	0	1,545	0

*--Timber stand improvement includes release, precommercial thinning, and understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Ground Applications		Aerial Application	
	% Selective	% Broadcast	% Selective	% Broadcast
Wildlife (incl. T&E) habitat	100	0	0	0
Balds habitat	100	0	0	0
Trails; Recreation sites	100	0	0	0
Roads-Forest Service	40	60	0	0
Roads-Co/State; Railroads	20	80	0	0
Power lines	40	60	0	100
Gas lines	40	60	0	0
Site prep./TSI-Pine	90	10	0	0
Site prep./TSI-Hardwood	100	0	0	0

6. Alternative E

Theme	Use of prescribed fire and herbicides declines from the present, and use of manual and mechanical methods increases. This alternative was developed to respond to those who want less reliance on man-made chemicals and prescribed fire.

Number of acres treated and frequency of treatments are at present levels, except for a reduction in hazardous fuel treatment. Intensity of treatments is reduced from the present to lessen potential adverse effects on human healt and safety, non-target plants and animals, soil, and water Acres treated per year total 2.4 percent of national fores land in the Appalachians.

The largest acre shifts among methods occur in site preparation (from use of prescribed fire and herbicides to manual and mechanical methods), timber stand improvement (from use of herbicides to manual methods), and roadside maintenance (from use of herbicides to mechanical methods)

Prescribed fire acres are decreased most by reduced frequency of hazardous fuel treatment, but fire is nearly eliminated in site preparation. Use of herbicides is eliminated in wildlife habitat improvement and bald maintenance and sharply reduced in site preparation and roadside maintenance.

Added mitigation measures beyond those presently required are applied. All those listed in section II.E apply excep for 2.c.(18,26).

Methods and Tools

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses a hazardous fuel reduction and wildlife habitat improvement.

Herbicides: Herbicides with least health and environmenta risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), and machine (boom sprayer, granular spreader). Major uses are site preparation and release. Selective treatments only are allowed in hardwood site preparation and release and maintenance of trails and recreation areas. Broadcast treatments are allowed only in pine site preparation and release and maintenance of roadsides and utility lines, an then only when site conditions require broadcast treatment

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are pine and hardwood site preparation, pine and hardwood timber stand improvement, and trail and roadside maintenance.

Mechanical: Only low to moderate disturbance tools (mowin chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance, wildlife habitat improvement, recreation area maintenance, and pine site preparation.

Biological: Light to moderate livestock grazing is used fo vegetation management only on larged, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
Gas lines	2
T&E habitat; FS roads; Balds (other)	3
Other wildlife habitat	4
Power lines	6
Hazardous fuels	9

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	30,902	25.2
Herbicides	12,593	10.3
Manual	46,844	38.3
Mechanical	29,191	23.9
Biological	2,837	2.3
	122,367	100.0

Alternative E

Projected acres/year by method by program:

Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	12,593	29,191	30,902	46,844	2,837
Fuels treatment	0	0	15,355	0	0
T&E species habitat	0	0	2,883	202	0
Other wildlife habitat	0	8,055	10,954	1,205	0
Balds habitat	0	233	994	175	2,837
Trails	38	193	0	3,616	0
Recreation sites	395	4,173	0	1,392	0
Roads-Forest Service	600	9,141	0	2,140	0
Roads-Co/State	799	2,771	0	310	0
Power lines	337	589	0	196	0
Railroads	12	13	0	7	0
Gas lines	11	191	0	45	0
Site prep.-Pine	2,575	3,832	616	8,104	0
Site prep.-Hardwood	2,073	0	0	18,881	0
TSI-Pine*	5,061	0	100	7,790	0
TSI-Hardwood*	692	0	0	2,781	0

*--Timber stand improvement - Includes release, precommercial thinning, and understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program*	Percent Selective	Percent Broadcast
Trails; Recreation sites	100	0
Roads-Forest Service	30	70
Roads-Co/State; Railroads	10	90
Utility (power/gas) lines	40	60
Site prep./TSI-Pine	80	20
Site prep./TSI-Hardwood	100	0

7. Alternative MODIFIED E

This alternative was suggested by ForestWatch, an environmental coalition in northern Georgia which commente on the Draft EIS (volume III, letter 455). It also approximates similar suggestions by other commenters. As alternative E, use of prescribed fire and herbicides declines from the present, and use of manual and mechanica methods increases.

This alternative is nearly identical to alternative E with three major exceptions. First, herbicide use is eliminate along trails and in recreation sites as in alternative F, lessen real or perceived human exposure to herbicides. Second, site preparation and timber stand improvement for pines only are reduced by half; as a result, number of acr treated declines from the present. Third, use of prescrib fire is increased from alternative E in pine and hardwood site preparation.

This alternative's actions and effects fall within the ran of those analyzed in the Draft EIS. Added mitigations beyond those presently required are applied. All those listed in section II.E apply except 2.c.(18,26).

Methods and Tools

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses a hazardous fuel reduction and wildlife habitat improvement.

Herbicides: Herbicides with least health and environmenta risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), and machine (boom sprayer, granular spreader). Major uses are site preparation and release. Selective treatments only are allowed in hardwood site preparation and release. Broadca treatments are allowed only in pine site preparation and release and maintenance of roadsides and utility lines, an then only when site conditions require broadcast treatment

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are pine and hardwood site preparation, pine and hardwood timber stand improvement, and trail and roadside maintenance.

Mechanical: Only low to moderate disturbance tools (mowin chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance wildlife habitat improvement, and recreation area maintenance.

Biological: Light to moderate livestock grazing is used f vegetation management only on larged, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
Gas lines	2
T&E habitat; FS roads; Balds (other)	3
Other wildlife habitat	4
Power lines	6
Hazardous fuels	9

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	33,833	31.2
Herbicides	7,529	7.0
Manual	38,697	35.7
Mechanical	25,432	23.5
Biological	2,837	2.6
	108,328	100.0

Alternative MODIFIED E

Projected acres/year by method by program:

Program	Method				
	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	7,529	25,432	33,833	38,697	2,837
Fuels treatment	0	0	15,355	0	0
T&E species habitat	0	0	2,883	202	0
Other wildlife habitat	0	8,055	10,954	1,205	0
Balds habitat	0	233	994	175	2,837
Trails	0	192	0	3,655	0
Recreation sites	0	4,172	0	1,788	0
Roads-Forest Service	594	8,911	0	2,376	0
Roads-Co/State	776	2,716	0	388	0
Power lines	337	561	0	224	0
Railroads	0	16	8	8	0
Gas lines	5	198	0	44	0
Site prep.-Pine	1,134	378	3,026	3,026	0
Site prep.-Hardwood	1,573	0	563	18,818	0
TSI-Pine*	2,418	0	50	4,007	0
TSI-Hardwood*	692	0	0	2,781	0

*--Timber stand improvement - Includes release, precommercial thinning, and understory species treatments.

Percent of herbicides applied using selective versus broadcast techniques:

Program	Percent Selective	Percent Broadcast
Roads-Forest Service	40	70
Roads-Co/State; Railroads	20	80
Utility (power/gas) lines	40	60
Site prep./TSI-Pine	90	10
Site prep./TSI-Hardwood	100	0

8. Alternative F

Theme

Use of herbicides is eliminated. Use of prescribed fire, manual, and mechanical methods expands from the present to make up for the loss of herbicides. This alternative was developed to respond to those who oppose use of man-made chemicals.

Number of acres and frequency of treatments are at present levels, but intensity of treatments is reduced to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 2.5 percent of national forest land in the Appalachians.

The largest acre shifts from use of herbicides occur in timber stand improvement (all to manual methods), site preparation (about equally to prescribed fire and manual and mechanical methods), and roadside maintenance (mostly to mechanical methods).

Added mitigation measures beyond those presently required are applied. All those listed in section II.E apply except for herbicides (the 2.c group).

Methods and Tools

Prescribed Fire: Only low to moderate intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and pine site preparation.

Herbicides: Herbicide use is not allowed.

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are hardwood site preparation, pine and hardwood timber stand improvement, and trail and roadside maintenance.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance, wildlife habitat improvement, recreation area maintenance, and pine site preparation.

Biological: Light to moderate livestock grazing is used for vegetation management only on large, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs).
Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
Gas lines	2
T&E habitat; FS roads; Balds (other)	3
Other wildlife habitat	4
Hazardous fuels; Power lines	6

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	47,657	36.6
Herbicides	0	0.0
Manual	49,765	38.3
Mechanical	29,786	22.9
Biological	2,837	2.2
	130,045	100.0

Alternative F

Projected acres/year by method by program:

	Method				
Program	Herbicides	Mech.	Fire	Manual	Biol.
Projected acres/year	0	29,786	47,657	49,765	2,837
Fuels treatment	0	0	23,033	0	0
T&E species habitat	0	0	2,883	202	0
Other wildlife habitat	0	8,126	11,969	119	0
Balds habitat	0	233	994	175	2,837
Trails	0	192	0	3,655	0
Recreation sites	0	4,172	0	1,788	0
Roads-Forest Service	0	9,445	0	2,436	0
Roads-Co/State	0	3,182	0	698	0
Power lines	0	337	0	785	0
Railroads	0	7	0	25	0
Gas lines	0	178	0	69	0
Site prep.-Pine	0	3,914	8,274	2,939	0
Site prep.-Hardwood	0	0	126	20,828	0
TSI-Pine*	0	0	378	12,573	0
TSI-Hardwood*	0	0	0	3,473	0

*--Timber stand improvement includes release, precommercial thinning, and understory species treatments.

9. Alternative G

Theme

Use of prescribed fire is eliminated. Use of herbicides, manual, and mechanical methods expands from the present to make up for the loss of herbicides, except in fuels treatment where this is not possible. This alternative was developed to respond to those who oppose use of prescribed fire.

Number of acres and frequency of treatments are at present levels, except for elimination of hazardous fuel treatment. Intensity of treatments is reduced from the present to lessen potential adverse effects on human health and safety, non-target plants and animals, soil, and water. Acres treated per year total 2.1 percent of national forest land in the Appalachians.

The largest acre shifts from use of prescribed fire occur in wildlife habitat improvement (mostly to herbicides and manual methods), pine site preparation (equally to herbicides and manual and mechanical methods), and bald maintenance (about equally to herbicides and manual and mechanical methods).

Aerial application of herbicides is allowed on selected utility lines and pine site preparation projects.

Added mitigation measures beyond those presently required are applied. All those listed in section II.E apply except for prescribed fire (the 2.b group).

Methods and Tools

Prescribed Fire: Use of prescribed fire is not allowed.

Herbicides: Herbicides with least health and environmental risks (table II-1) are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and helicopter (granular and liquid systems). Major uses are pine and hardwood timber stand improvement, pine and hardwood site preparation, wildlife habitat improvement, and roadside maintenance. Selective treatments only are allowed in hardwood site preparation and timber stand improvement and maintenance of wildlife habitat, trails, balds, and recreation areas. Broadcast treatments are allowed only in pine site preparation and release and maintenance of roadsides and utility lines, and then only when site conditions require broadcast treatments. Aerial application is allowed on selected utility lines and pine site preparation projects (2,100 acres projected per year).

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are pine and hardwood site preparation, trail and roadside maintenance, pine and hardwood timber stand improvement, and wildlife habitat improvement.

Mechanical: Only low to moderate disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, light disking) are allowed. Major uses are roadside maintenance, wildlife habitat improvement, recreation area maintenance, and pine site preparation.

Biological: Light to moderate livestock grazing is used for vegetation management only on large, fenced grass balds.

	Area Treated	Intervals (Yrs.)
Projected Average Treatment Frequency	Trails; Co/St roads; RR's; Rec. sites; Balds (grazed)	1
	Gas lines	2
	T&E habitat; FS roads; Balds (other)	3
	Other wildlife habitat	4
	Power lines	5
	Hazardous fuels	None

	Method	Projected Acres/Yr	Percent Total Acres Treated
Estimated Program	Fire	0	0.0
	Herbicides	37,440	35.0
	Manual	38,729	36.2
	Mechanical	27,906	26.1
	Biological	2,837	2.7
		106,912	100.0

Alternative G

Projected acres/year by method by program:

	Method					
Program	Herbicides		Mech.	Fire	Manual	Biol.
	Ground	Aerial				
Projected acres/year	35,340	2,100	27,906	0	38,729	2,837
Fuels treatment	0	0	0	0	0	0
T&E species habitat	574	0	574	0	1,937	0
Other wildlife habitat	9,347	0	8,637	0	2,230	0
Balds habitat	1,052	0	280	0	70	2,837
Trails	77	0	192	0	3,578	0
Recreation sites	596	0	4,172	0	1,192	0
Roads-Forest Service	1,188	0	8,554	0	2,139	0
Roads-Co/State	1,552	0	2,018	0	310	0
Power lines	73	600	337	0	112	0
Railroads	25	0	7	0	0	0
Gas lines	25	0	178	0	44	0
Site prep.-Pine	5,902	1,500	2,957	0	4,768	0
Site prep.-Hardwood	3,073	0	0	0	17,881	0
TSI-Pine*	10,428	0	0	0	2,423	0
TSI-Hardwood*	1,428	0	0	0	2,045	0

*--Timber stand improvement - Includes release, precommercial thinning, and understory species treatments.

Alternative G

Percent of herbicides applied using selective versus broadcast techniques:

Program*	Ground Applications % Selective	Ground Applications % Broadcast	Aerial Application % Selective	Aerial Application % Broadcast
Wildlife (incl. T&E) habitat	100	0	0	0
Balds habitat	100	0	0	0
Trails; Recreation sites	100	0	0	0
Roads-Forest Service	30	70	0	0
Roads-Co/State; Railroads	10	90	0	0
Utility (power/gas) lines	40	60	0	100
Site prep.-Pine	80	20	0	100
TSI-Pine	80	20	0	0
Site prep./TSI-Hardwood	100	0	0	0

10. Alternative H

Theme

Vegetation management is done to achieve maximum vegetation control within legal constraints. Use of herbicides broadcast at maximum rates, intensive mechanical tools, and intense prescribed fire expands from the present. This alternative was developed to establish a full range of alternatives and to respond to those who want maximum production of market goods.

Number of acres and intensity and frequency of treatments increase from present levels. Much of the increase in acres is due to increased treatment frequency for hazardous fuels, roadside maintenance, wildlife habitat improvement, and bald maintenance. But a large share is due to expansion of pine release, preharvest hardwood site preparation, and hardwood timber stand improvement on highly productive land where competition and return on investment are greatest. Acres treated per year total 3.3 percent of national forest land in the Appalachians.

Substantial shifts from present mix of methods occur in roadside maintenance (from use of mechanical methods to herbicides) and site preparation (from use of prescribed fire and herbicides to mechanical methods).

Only those mitigation measures presently required are applied. All those listed in section II.E apply except 1.h.(22,24), 2.a.(7,8,9), and 2.c. (3,4,5,6,13,14,17,19).

Methods and Tools

Prescribed Fire: Low to high intensity burns are applied by ground and aerial ignition tools. Major uses are hazardous fuel reduction, wildlife habitat improvement, and pine site preparation.

Herbicides: Herbicides are applied by hand (backpack sprayer, spotgun, hypo-hatchet, injector, axe/sprayer), machine (boom sprayer, granular spreader), and helicopter (granular and liquid systems). Major uses are pine and hardwood timber stand improvement, pine and hardwood site preparation, and roadside maintenance. Aerial application is allowed on utility lines, pine site preparation and release projects, and balds (8,700 acres projected per year).

Manual: Hand (axe, blade, clipper) and power tools (chain saw, brush cutter) are allowed. Major uses are hardwood site preparation, pine and hardwood timber stand improvement, and trail maintenance.

Mechanical: Low to high disturbance tools (mowing, chopping, shearing, ripping, scarifying, piling, disking, raking) are allowed. Major uses are wildlife habitat improvement, roadside maintenance, and recreation area maintenance.

Biological: Light to moderate livestock grazing is used for vegetation management only on large, fenced grass balds.

Projected Average Treatment Frequency

Area Treated	Intervals (Yrs.)
Trails; Co/St roads; RR's; Gas lines, Rec sites; Balds	1
FS roads; Balds (ungrazed)	2
T&E habitat; Other wildlife habitat	3
Hazardous fuels; Power lines	4

Estimated Program

Method	Projected Acres/Yr	Percent Total Acres Treated
Fire	60,109	35.0
Herbicides	50,984	29.7
Manual	35,180	20.5
Mechanical	22,561	13.1
Biological	2,837	1.7
	171,671	100.0

Alternative H

Projected acres/year by method by program:

	Method				
Program	Herbicides		Mech.	Fire	Manual
	Ground	Aerial			
Projected acres/year	42,284	8,700	22,561	60,109	35,180
Fuels treatment	0	0	0	34,550	0
T&E species habitat	0	0	0	2,883	202
Other wildlife habitat	87	0	8,121	16,196	130
Balds habitat	231	400	315	1,052	105
Trails	77	0	192	0	3,578
Recreation sites	594	0	4,173	0	1,193
Roads-Forest Service	10,008	0	5,681	0	2,140
Roads-Co/State	2,552	0	1,017	0	310
Power lines	176	800	572	0	136
Railroads	25	0	7	0	0
Gas lines	48	0	356	0	90
Site prep.-Pine	2,574	2,500	2,127	4,987	2,939
Site prep.-Hardwood	8,312	0	0	63	17,818
TSI-Pine*	15,272	5,000	0	378	4,391
TSI-Hardwood*	2,328	0	0	0	2,148

*--Timber stand improvement includes release, precommercial thinning, and unders
species treatments.

Alternative H

Percent of herbicides applied using selective versus application techniques:

Program	Ground Applications % Selective	Ground Applications % Broadcast	Aerial Application % Selective	Aerial Application % Broadcast
Other wildlife habitat	90	10	0	0
Balds habitat	80	20	0	100
Trails; Recreation sites	100	0	0	0
Roads-Forest Service	10	90	0	0
Roads-Co/State; Railroads	10	90	0	0
Utility (power/gas) lines	20	80	0	100
Site prep.-Pine	40	60	0	100
TSI-Pine	60	40	0	100
Site prep./TSI-Hardwood	100	0	0	0

C. ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Custodial Vegetation Management: This alternative would allow vegetation management only to protect public health and safety and crucial forest resources. Activities would be limited to hazardous fuel reduction, corridor maintenance, and protection of threatened and endangered (T&E) species. It was eliminated from detailed study because other alternatives (A and B) adequately address these concerns and effects.

No Mechanical Methods: This alternative would ban use of mechanical methods. It was eliminated from detailed study because there was no issue regarding the elimination of mechanical treatments, and the effects of severely restricted mechanical treatments are analyzed in alternative B.

No Prescribed Fire or Herbicides: This alternative would ban use of both prescribed fire and herbicides. It was eliminated from detailed study because there were no issues regarding the elimination of these two methods. Alternatives A, F, and G allow comparable analysis.

Little Prescribed Fire or Herbicides: This alternative was suggested by several people from North Carolina who commented on the Draft EIS. They recommended a vegetation management program of about 106,000 acres per year whose mix of methods would be 45 percent manual, 44 percent mechanical, 5 percent prescribed fire, 5 percent herbicides, and 1 percent biological.

In many respects this alternative is very similar to alternatives B and Modified E which effects are already analyzed in the Final EIS. When considering this alternative, we evaluated the requirements for each method as related to the various activities that were within the scope of the EIS and determined two limiting factors. First, the 5 percent level for prescribed fire will not meet the minimum needs (20-25 percent) which is necessary to reduce hazard fuel buildups, maintain fire-dependent ecosystem and meet critical wildlife habitat needs. There is no practical substitute for this method and the effects of a similar level of prescribed fire are already analyzed in detail in alternative B. Second, mechanical methods have limited applicability for fuel treatment, hiking trail maintenance, hardwood site preparation, pine and hardwood release, and heath bald maintenance. Also mechanical tools have operational limitations that restrict their use on both steep slopes or rocky terrain, which is so prevalent in the Appalachian Mountains. This limitation prohibits this method to be feasible at the recommended 44 percent level. Therefore, because of the above reasons it was eliminated from detail study.

D. DESCRIPTION OF METHODS AND TOOLS

This section describes methods and tools proposed for use in the vegetation management program. Methods discussed are prescribed fire, mechanical, manual, herbicides, and biological. Regardless of the harvest cutting methods identified in Forest Land and Resource Management Plans, of the tools described in this section are available for as specified by each alternative.

1. Prescribed Fire

Prescribed fire is the planned use of fire. It is used t reduce hazardous fuels, prepare sites for seeding or planting, rejuvenate wildlife forage species, maintain fire-dependent species and ecosystems, control insects an diseases, maintain mountaintop balds, and manage wilderne and threatened and endangered species and their habitat. Factors evaluated when using prescribed fire include proj objectives, fuels (quantity, type, distribution, moisture content), topography (ruggedness, elevation, slope), weat (temperature, wind, humidity), time of year, smoke dispersal, and predicted fire behavior (flame length, rat of spread).

Firing techniques are the patterns used to dispense fire. The six techniques commonly used are backing fires, strip-head fires, flanking fires, spot fires, ring fires, and slash pile or windrow fires (figure II-1).

Backing fires consist of burning a fire against the wind. Strip-head fires are a series of parallel lines of fire s against the wind, perpendicular to wind direction; lines burn with the wind but never gain momentum before burning into the next line. Flanking fires are a series of lines fire set against the wind, parallel to wind direction, th burn out at right angles from the wind direction. Spot fires are a series of parallel fire spots (approximately 5 to 250 feet apart) set against the wind. The fires radiat out in all directions, minimizing fire momentum as they bu together. Ring fires are applications of a single line of fire completely around burn areas. Slash pile or windrow fires are applied to concentrated fuel piles.

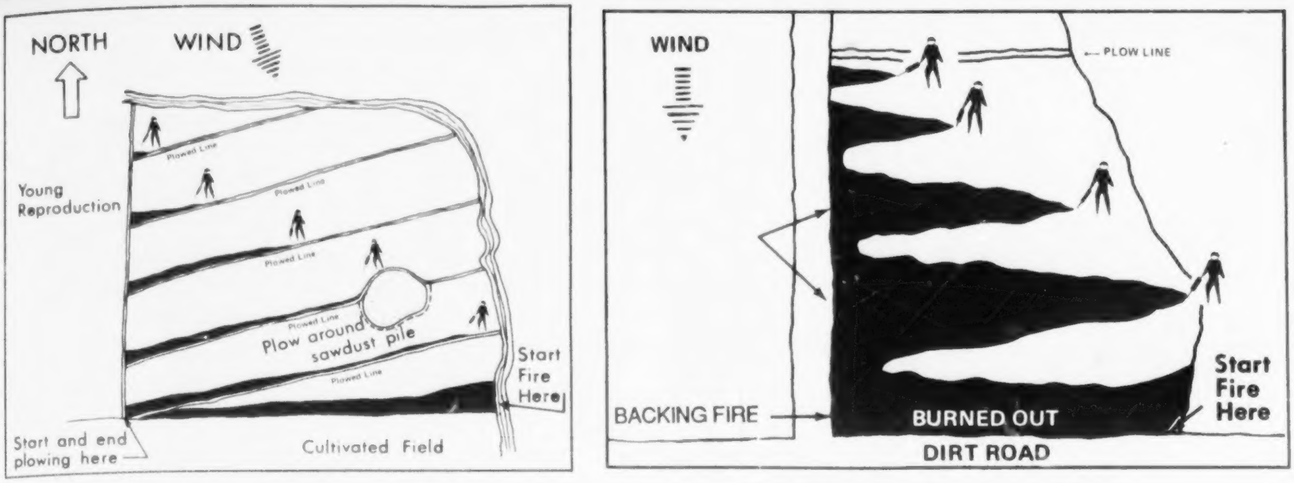
Three types of *ignition tools* are commonly used in the Appalachians. The traditional ground-based system is the hand-held drip torch. The other two tools, which are aeri ignition systems, are the helitorch and plastic sphere dispenser. Choice of firing technique and ignition tool depends on project objectives, site conditions, and safety

a. Hand-held Drip torch

Drip torches are small hand-held aluminum or stainless ste tanks that contain a mixture of gasoline and diesel fuel. spout attached to the tank drips the fuel mixture onto a lighted wick. Lighted fuel falls to the ground igniting surface fuels. All six firing techniques can be applied using hand-held drip torches.

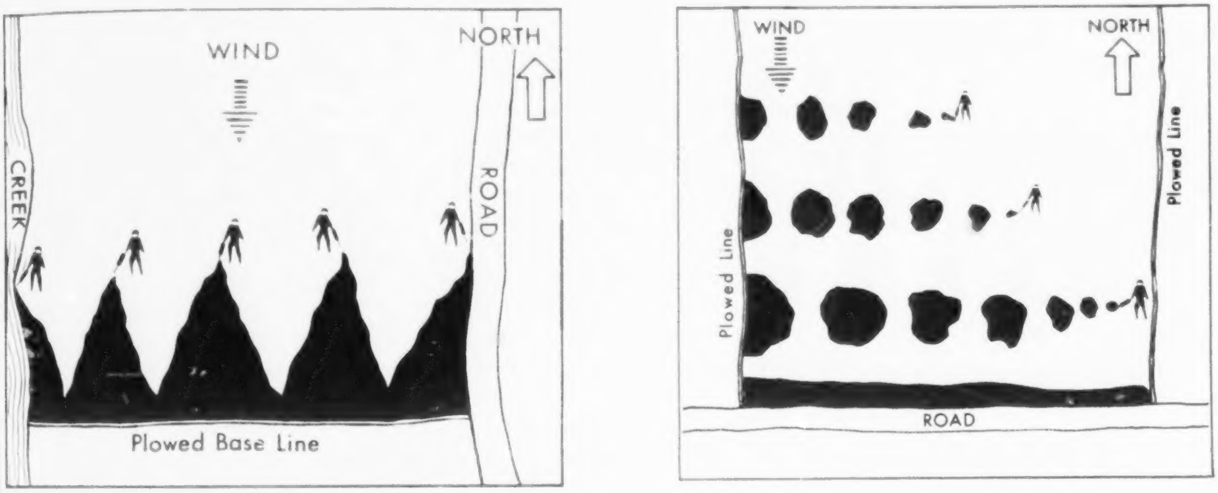
b. Helitorch

Helitorches are specially designed drip torches for application of ignited gelled fuel from helicopters. They consist of a 30- or 50-gallon fuel drum, an ignition and


NORTH
WIND
Young Reproduction
Plowed Line
Plowed Line
Plowed Line
Plowed Line
Plow around sawdust pile
Plowed Line
Start Fire Here
Start and end plowing here
Cultivated Field
WIND
PLOW LINE
BACKING FIRE
BURNED OUT
DIRT ROAD
Start Fire Here

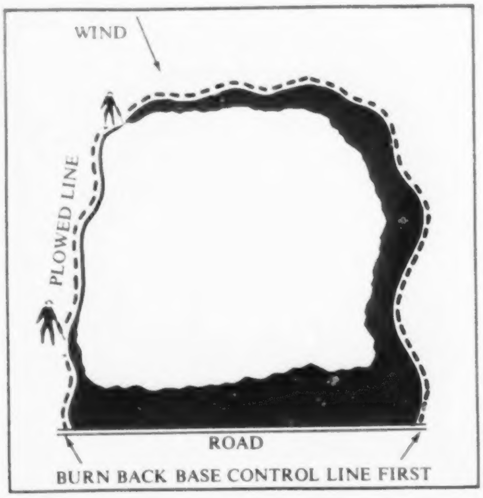
BACKING FIRE TECHNIQUE

STRIP-HEAD FIRE TECHNIQUE


WIND
NORTH
CREEK
ROAD
Plowed Base Line
WIND
NORTH
Plowed Line
Plowed Line
ROAD

FLANK FIRE TECHNIQUE

SPOT FIRE TECHNIQUE


WIND
PLOWED LINE
ROAD
BURN BACK BASE CONTROL LINE FIRST

RING FIRE TECHNIQUE

Figure II-1.--Firing techniques.

electric pump assembly, and frame and suspension system. The helitorch is suspended laterally beneath and to the front of a helicopter. The nozzle end of the torch is positioned on the same side as the pilot. The pilot controls flow and ignition of the gelled fuel. Gelled fuel is formed by adding a fuel thickening powder to regular gasoline or a 70-30 mixture of diesel fuel and gasoline. The strip-firing technique is most commonly used, although helitorch can be used with all firing techniques.

c. Plastic Sphere Dispenser

The plastic sphere dispenser is also applied using helicopters but the tool is mounted just inside the side door of a helicopter. The device ejects small spheres (commonly called "ping-pong balls"), made of high-impact polystyrene, approximately 1.25 inches in diameter, and filled with 3 grams of potassium permanganate (a dark purpl salt used as an oxidizer). Immediately prior to ejection, the spheres are injected with about 1 milliliter of ethylen glycol (antifreeze). Spheres are dropped onto the treatmen area at predetermined spacings (one or more per acre). After a delay of approximately 20 seconds, a reaction between the two chemicals ignites the sphere which sets fir to the surface fuels. The spot-firing technique is applied when using the plastic sphere dispenser.

2. **Mechanical Methods**

Eight types of mechanical tools are used on Appalachian national forests. They are divided into three categories based on their potential for soil disturbance by erosion, compaction, and nutrient loss. Potential soil disturbance is low for mowing, chopping, shearing, scarifying, and ripping tools; moderate for piling tools; and high for raking and disking tools.

a. Mowing Tools

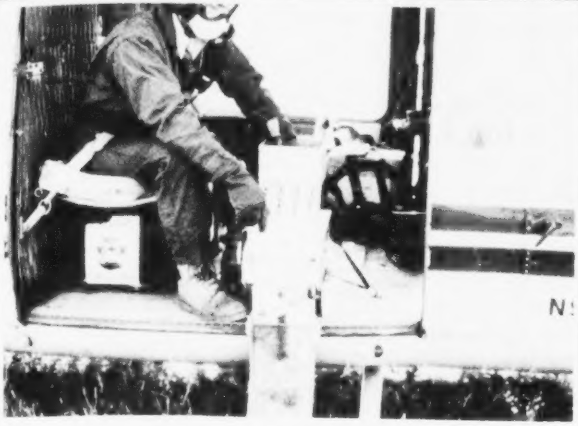
Mowing tools are rotary cutting devices that cut, chop, or shred vegetation on slopes up to 30 percent. Herbaceous species (grasses, grass likes, forbs) as well as woody species (vines, shrubs, trees) are cut near the ground line and are mulched and scattered, facilitating on-site decomposition and nutrient cycling. These tools are most effective on vegetation 3 inches or less in diameter. They are commonly used to maintain road and utility rights-of-way, refurbish wildlife food plots, maintain mountain balds, and precommercially thin young stands. Since mowing tools cut vegetation above the ground line, little soil is disturbed.

Sprouting species require repeated treatments because they rapidly recover and compete with desirable vegetation. In addition, as the material is cut it can be ejected out from the machine causing a safety hazard to workers or bystander

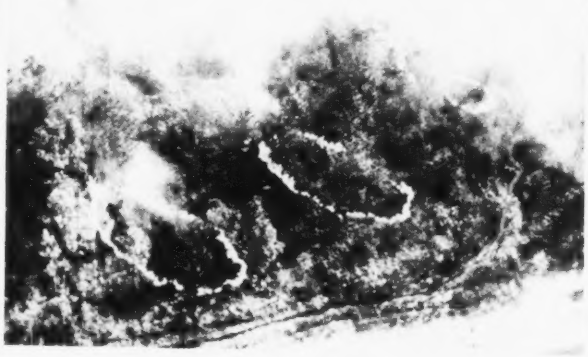
b. Chopping Tools

The most common chopping tool is a single rolling drum chopper towed by a crawler tractor. It cuts and chops herbaceous and woody vegetation up to 5 inches in diameter and operates on slopes up to 35 percent. Vegetation is pushed to the ground and cut into small pieces as the

PRESCRIBED FIRE TOOLS

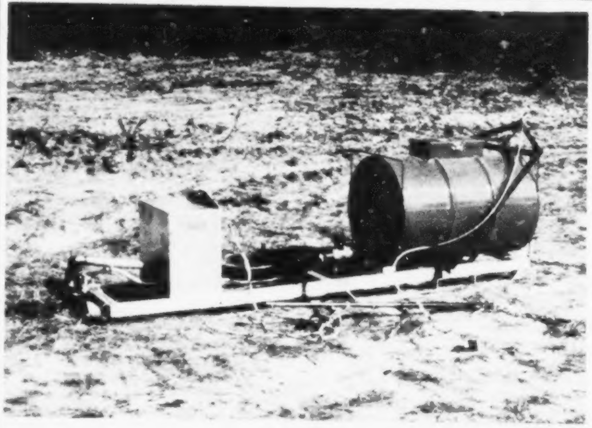


Aerial Ignition Device

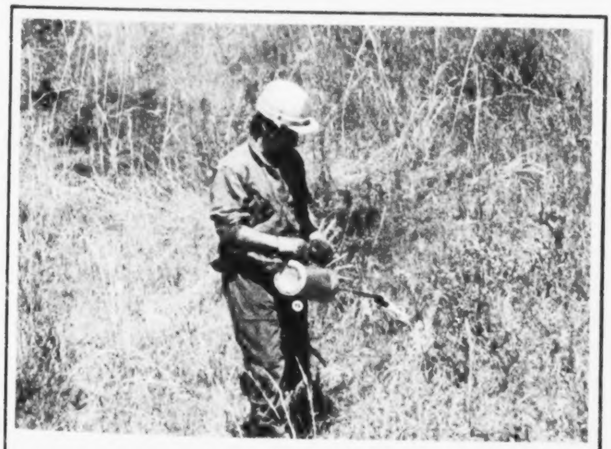


Spot firing technique

Helitorch in operation



Helitorch



Hand held drip torch

Helitorch

chopper rolls over it. Chopping tools are used mainly for site preparation but they are also used for rights-of-way maintenance and precommercial thinning.

Vegetation is cut and chopped into small pieces, which hel decomposition and nutrient cycling. Depressions made by chopping blades also increase water infiltration and mixin of organic matter into the soil. Soil exposure and disturbance are minor.

Release treatments may be needed because of rapid recovery of sprouting species, and debris left in place may impair planting. Soil exposure can be significant at the upper e of the tool's slope range.

c. Shearing Tools

Shearing tools are specialized cutting blades mounted on crawler tractors. The two types used are K-G ("angle") blades and V-blades. They are used on slopes up to 35 percent. Any size of herbaceous and woody vegetation can cut just above the ground line. This equipment is used fo site preparation and provides a cleared area ready for direct seeding or planting.

As material is pushed aside, topsoil can be displaced, whi increases risk of erosion. Sprouting species recover quickly and compete with desired vegetation.

d. Scarifying Tools

Scarifying tools clear herbaceous and small woody vegetation; their rotating scalping blades form a shallow depression, 2-4 inches deep, with an adjacent pile of topsoil. The modified area is approximately 18 inches by feet. Size and spacing of scalped areas can be varied. O the average, cleared areas are on a 7-foot by 7-foot spacing. Scarifiers are usually towed behind a crawler tractor or rubber-tired skidder on slopes up to 35 percent They are used mainly for site preparation.

Scarifiers modify soil moisture and nutrient conditions. Depressions increase water storage, and adjacent piles hav increased soil drainage and concentrated nutrients. Clear areas are not continuous and ground cover between them is usually not disturbed, so risk of erosion and nutrient los is very low.

Efficiency of scarifiers is reduced on steep slopes, shall soils, and sites having many obstacles such as large rocks stumps, or logs. Additional treatments, such as herbicide application alongside scalped areas or subsequent release after seeding or planting, may be necessary on sites with abundant understory vegetation to reduce competition aroun cleared areas.

e. Ripping Tools

Ripping tools (also called subsoilers or chisel plows) are large blades or shanks pulled through the soil at depths of 4 to 20 inches. Spacing between rips varies from 3 to 12 feet. The exposed soil ranges from 6 to 24 inches wide. Because of the blades' size and tilling depth, rippers are usually mounted on or pulled behind large farm or crawler tractors. Ripping is usually done on the contour of slopes up to 35 percent. Rips placed on the contour can be continuous, but rips not on the contour are broken up by lifting the blades out of the ground every 50 to 100 feet. Some wildlife habitat improvement projects use rippers, but they are mainly used for natural or artificial site preparation.

Rippers break up and mix compacted soils and improve soil porosity. This action forms a microsite more suitable for seeding or planting by improving soil drainage and available moisture. Risks of erosion are very low when ripping is done on the contour, as the undisturbed area between rips and the contour berms trap nearly all eroded soil. Such risks increase when done up and down slopes.

High amounts of logging slash, standing residual trees, or woody understory vegetation reduce ripping efficiency. Treatments such as prescribed burning or shearing and piling prior to ripping may be necessary on such sites to facilitate ripping.

f. Piling Tools

Piling tools move logging slash and woody understory vegetation into piles or windrows. The piling tool is commonly called a brush rake or piling and stacking rake. It replaces the dozer blade on a crawler tractor and is used on slopes up to 35 percent. It is not solid like a standard dozer blade, but consists of a series of curved teeth spaced at intervals of 6 to 24 inches. The rake is held above the soil surface, and logging slash and brush are rolled forward into piles or windrows. Piling tools are used mainly for preparing sites for artificial regeneration.

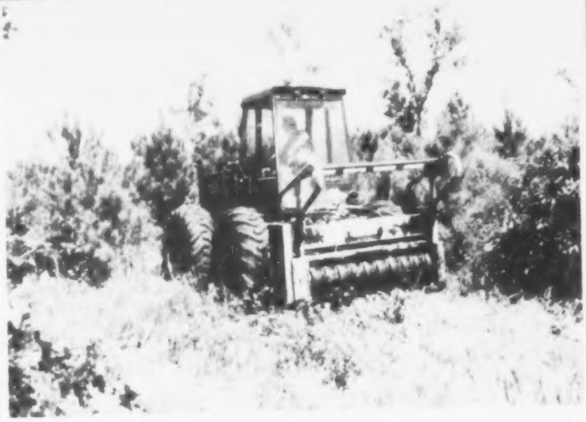
Teeth of the rake do not penetrate the soil and are curved to produce a rolling motion of material being piled, which creates a moderate amount of soil disturbance. As the material is rolled forward, nearly all topsoil and much litter filter through the spacings between the rake teeth.

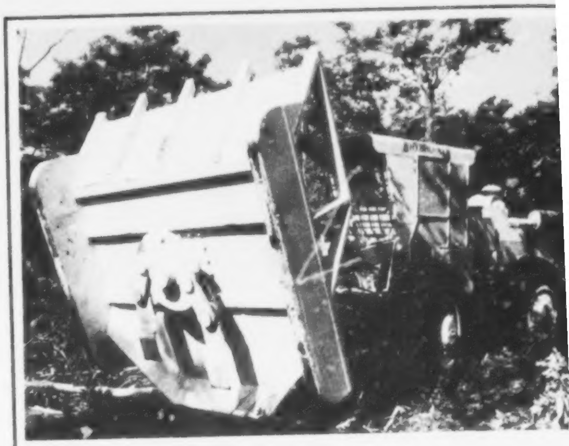
g. Raking Tools

Raking tools also move logging slash and woody understory vegetation into piles or windrows. Rakes are standard dozer blades or brush rakes mounted on a crawler tractor. They can operate on slopes up to 35 percent. Raking tools are used mainly for preparing sites for artificial regeneration.

Raking differs from piling. A standard solid dozer blade pushes material forward with little rolling action. This action causes logging slash, brush, litter, and some topsoil

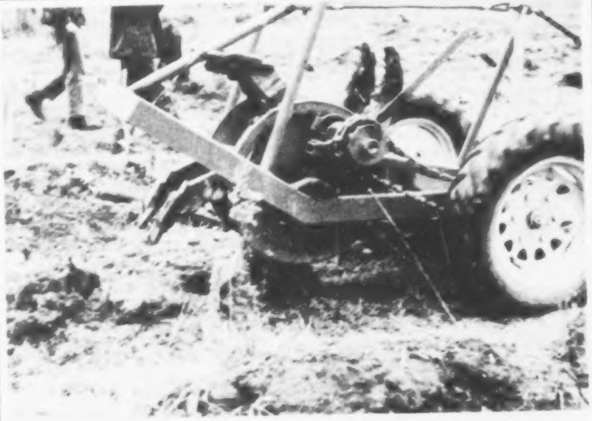
MECHANICAL TOOLS (1)


Mowing tool - Shredder


Mowing tool - Hydro Axe

Mowing tool - Bush-hog

Ripping tool


Scarifying tool

Mowing tool - sickle bar

to be scraped into the piles or windrows. When using a brush rake, the teeth are lowered to penetrate the soil, uprooting and pushing herbaceous and small woody vegetation ("root-raking") as well as litter and some topsoil along with the logging slash and brush into the piles. Soil disturbance from raking is high.

h. Disking Tools

Disking tools consist of one or more sets of disks pulled behind a farm or crawler tractor. Disks plow by tilling and mixing topsoil and litter to depths of 4 to 20 inches. Disking is usually done on the contour on slopes up to 30 percent. Disking tools are mainly used for wildlife habitat maintenance.

Disking is divided into light and heavy categories based on intensity of tilling. Light disking is done to shallow depths on small areas (usually less than 1 acre), in strips, or on slopes of 5 percent or less. Undisked strips act as filter strips that reduce soil loss. Examples of light disking are wildlife opening refurbishment and reseeding of logging roads and skid trails. Heavy disking is commonly done to greater depths over large areas at slopes steeper than 5 percent.

Efficiency of disking is reduced on areas with many obstacles, such as large rocks, logs, or stumps, which could damage disks. On areas with heavy logging slash or abundant brush, common treatments prior to disking include shearing followed by piling or raking. Disking can break up compacted surface soils.

3. Manual Methods

Manual methods use hand-operated powered or non-powered tools to cut, clear, thin, girdle, or prune herbaceous and woody species. Non-powered hand tools are axes, brush hooks, and hand clippers. Powered hand tools include chain saws and motorized brushcutters (weed eaters with a saw-type blade). Slope does not limit use of manual tools. Manual tools are most commonly used for timber stand improvement (release, precommercial thinning), corridor maintenance (especially trails), wildlife habitat improvement, mountain balds maintenance, and threatened and endangered species habitat improvement.

Manual cutting tools sever vegetation above the ground line; soil is seldom exposed. Residues are usually left intact on the treatment area, facilitating nutrient cycling as the materials slowly decompose. Heavy amounts of slash may initially cause an increase in fire hazard. Sprouting species rapidly recover and compete with desirable vegetation, requiring repeated manual treatments or the use of other treatments such as herbicides or prescribed fire.

4. Herbicide Methods

Characteristics of the 11 herbicides used in the Southern Region are described below, as are 3 application methods:

(1) manual ground, which uses hand-carried equipment; (2) mechanical ground, which uses truck- or tractor-mounted equipment; and (3) aerial, which uses helicopter mounted equipment.

Herbicides are applied as either liquid sprays or granules. All spray-application tools are designed to produce large droplets to minimize drift. Relatively large and heavy granules are also designed to minimize drift.

New herbicides and application methods are periodically registered for silvicultural use. Prior to operational use, efficacy of the herbicide is evaluated through research and administrative studies on small areas. If the product is effective, a supplement to this EIS will be prepared which includes a toxicological background statement, a risk assessment, and analysis of the product's environmental behavior. Once testing, documentation, and public disclosure of findings are complete, field personnel are notified of the availability of the new herbicide or tool.

a. Herbicides Characteristics

Primary sources of information are product labeling information, material safety and technical data sheets, the Weed Science Society of America's Herbicide Handbook (1983), and the Southern Region's annual herbicide use reports. Individual sources are not cited for each bit of data.

DICAMBA

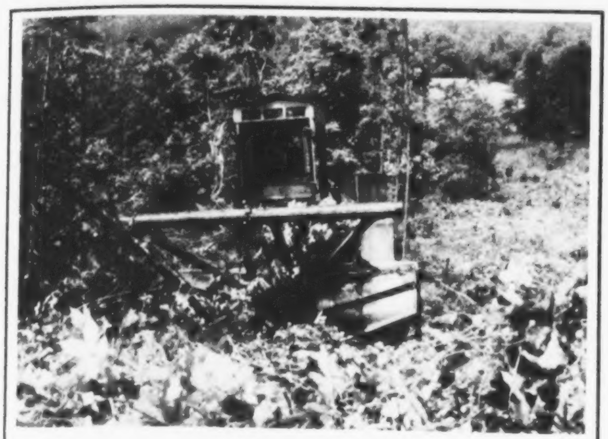
TRADE NAME: BANVEL^{R}, BANVEL^{R} CST, BANVEL^{R} 720, and others.

Dicamba is regularly used for broadleaf weed control in food crops including small grains, corn, sorghum, sugarcane, and asparagus. Additionally, it has labeled uses for weed control in turfgrass and utility rights-of-way. In forestry, its labeled use is for woody plant control in site preparation. In the South, dicamba is not widely used in forestry work. Methods of application include cut-surface treatments, basal spray, and foliar spray. Dicamba is readily absorbed and translocated by the roots, stems, and foliage of plants. In susceptible species, dicamba acts primarily as a growth regulator affecting shoot and root development. The degree of effect varies by species. Dicamba may be broken down by the plant or moved through the roots to surrounding soil. Dicamba may move in the soil, especially sandy soils. Micro-organisms biodegrade dicamba in soil. It persists in the soil from 3 to 12 weeks depending on weather.

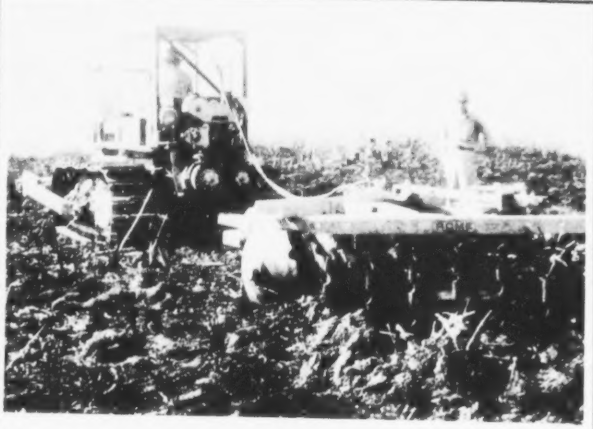
FOSAMINE

TRADE NAME: KRENITE^{R}, KRENITE^{R} S.

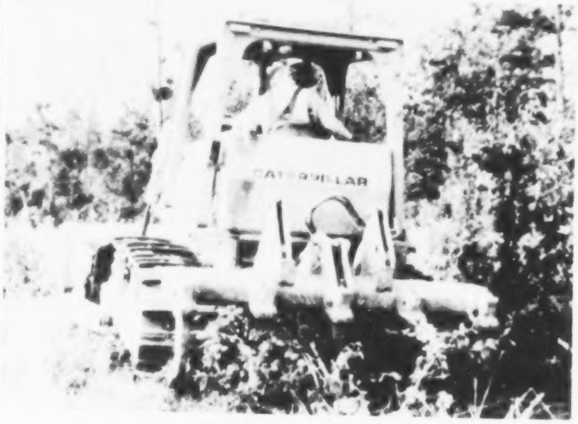
Fosamine ammonium is labeled for non-cropland brush control on railroads, rights-of-way, industrial plant sites, MECHANICAL TOOLS (2)



Self propelled chopper

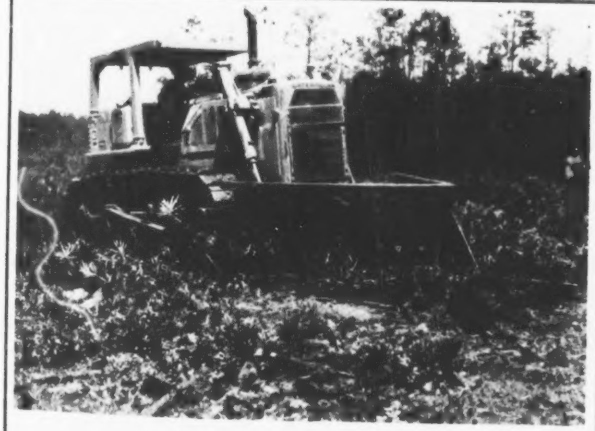


Heavy disking tool

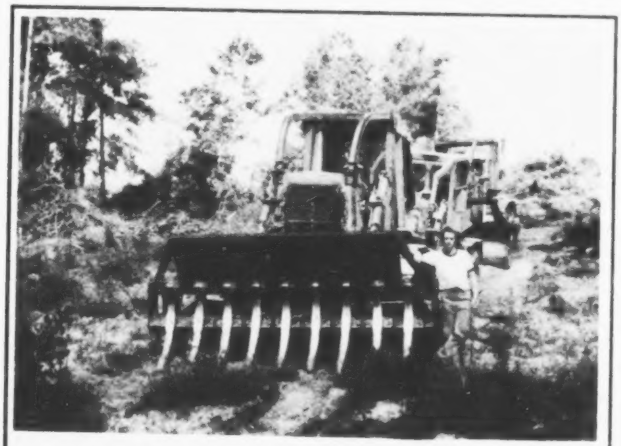


Ripping tool

Light disking tool



Shearing tool, V-blade



Piling tool - brush rake

drainage ditch banks, etc., including land surrounding wa supply reservoirs. In forestry it is seldom used, but is used for right-of-way maintenance. Method of application foliar spray, and coverage must be complete to be effective. Fosamine is absorbed by foliage, stems, and bu of broadleaf plants. The effects of this herbicide are delayed, and following a fall application, bud developmen in the spring is prevented or severely limited. There is little or no leaching of fosamine through soil. Field te have shown a half-life in soil of about 1 week.

GLYPHOSATE

TRADE NAME: ROUNDUP^R, RODEO^R, ACCORD^R, and others.

Glyphosate is commonly used in agriculture and as a home- product. It controls a broad range of grasses, weeds, an woody brush species. Roundup is registered for uses on orchards, groves, vineyards, and in weed control prior to planting of grains, soybeans, corn, and other food crops. It is also registered for control of grass and weeds in recreational areas, schools, parking lots, other public grounds, and for non-crop areas, forests and silvicultura sites. Rodeo is labeled primarily as an aquatic herbicid but is also labeled for forestry. Accord is registered f use on forests and industrial sites. Glyphosate is used forestry for site preparation and release. Methods of application include cut-surface treatments and foliar spray. Glyphosate is readily absorbed by foliage and primarily affects plants by disrupting photosynthetic processes. Glyphosate has practically no leaching tenden because it binds tightly to soil. In soil, it is highly susceptible to degradation by micro-organisms, being converted to natural products such as carbon dioxide and water. Persistence in soils is about 2 months or less.

HEXAZINONE

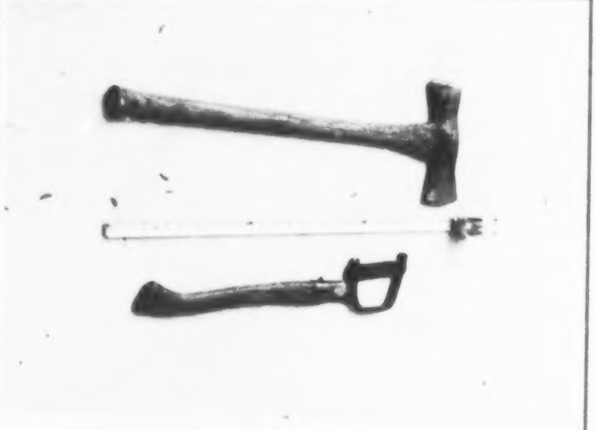
TRADE NAME: VELPAR^R L, Velpar^R ULW, PRONONE^R 5G, PRONONE 10G, and others.

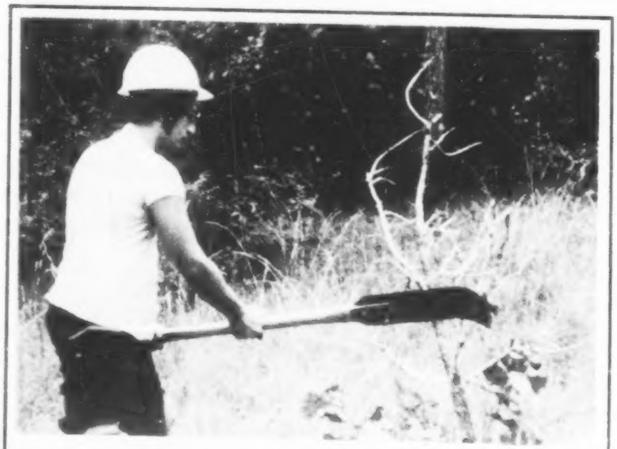
Hexazinone is used to control a wide variety of grasses, weeds, and woody plants. Hexazinone has a number of food crop uses including weed control in blueberries, sugarcan pineapple, and alfalfa. In forestry, it is commonly used for site preparation and release. Methods of application include foliar spray, basal soil applications, granular applications to soil, and cut-surface treatment. Hexazin is a "soil-active" herbicide, is readily moved into soil, and is absorbed by plant roots with some foliage absorption. Herbicide activity and lateral and vertical movement are limited in soils high in organic matter or heavy clay. It may affect nearby desirable plants outsid the treated area which have roots growing into the treate zone. Hexazinone primarily affects plants by inhibiting

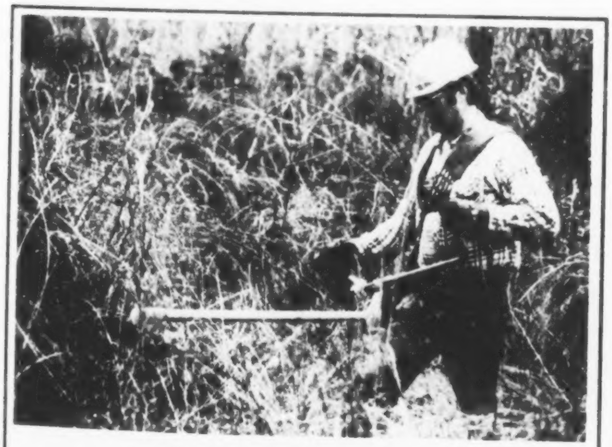
BIOLOGICAL AND MANUAL TOOLS

Cattle as a biological control tool

Chainsaw


Brush axes


Brush hook


Brushsaw

Horses as a biological control tool

photosynthesis. The degree of effect on plants depends on susceptibility of the species, rate of application, and soil texture. In soil, hexazinone is subject to microbial degradation. It persists in soil from 1 to 6 months depending on soil and weather.

IMAZAPYR

TRADE NAME: ARSENAL^R, ARSENAL^R Applicators Concentrate, CHOPPER^R, and others

Imazapyr is used for control of weeds, grasses, and woody plants in forestry including site preparation and release. It is also labeled for weed control under pavement at industrial sites and rights-of-way. Methods of application include cut-surface treatments, foliar spray, and basal bark spraying. Imazapyr is absorbed through foliage and roots and is rapidly moved throughout the plant. Imazapyr accumulates in growing tips of plants where it inhibits amino acid synthesis. It affects susceptible species slowly, yellowing newest leaves first and then spreading throughout the plant. Imazapyr can enter the soil, but lateral and vertical movement is limited. It persists in soil up to 12 months depending on soil type, amount used, and weather. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Imazapyr photodegrades and, to a lesser extent, biodegrades. Imazapyr has minimal effect on soil microflora.

PICLORAM

TRADE NAME: TORDON^R 101, TORDON^R 101R, TORDON^R K, and others.

Picloram's uses include noxious weed control, rights-of-way, facilities maintenance, and rangeland improvement. In forestry it is used to control woody plants and weeds. Methods of application include cut-surface treatments and foliar spray. Picloram is primarily a growth regulator. Herbicidal action is a result of absorption through leaves and some uptake through roots. It is easily translocated in plants and accumulates in new growth causing leaves to cup and curl. Picloram is water soluble and can move in sandy soils low in organic matter. It may affect nearby desirable plants outside the treated area which have roots growing into the treated zone. Degradation by soil micro-organisms is slow and primary breakdown is by ultra violet light. Persistence in soils varies by type of soil and weather but may exceed 100 days.

SULFOMETURON METHYL

TRADE NAME: OUST^R.

Sulfometuron methyl is a broad spectrum, pre- and post-emergence herbicide. Its labeled uses include selective weed control in turf grass, roadsides, and other non-cropland applications. It is registered for control of undesirable herbaceous plants in pine reforestation sites. The method of application normally is foliar spray. Sulfometuron methyl is absorbed through plant leaves, with some absorption by roots. In the plant, it suppresses and stops plant growth by arresting cell division in growing tips. Sulfometuron methyl is hydrolyzed in soil and persists approximately 4 weeks.

TEBUTHIURON

TRADE NAME: SPIKE^R (several formulations), GRASLAN^R, and others.

Tebuthiuron is a broad-spectrum, soil-applied herbicide used for weed and brush control in range, pasture, and non-cropland applications. Its labeled uses include control of woody plants and weeds for maintenance of utility rights-of-way. It is usually applied to the soil as a granule, pellet, or wettable powder. The mode of action of tebuthiuron in plants is to inhibit photosynthesis. It is slowly absorbed by plant roots and may take up to 3 years to kill some species. Tebuthiuron is moderately mobile in most soils and is persistent from 1 to 3 years. It may affect nearby plants outside the treated area that have roots growing into the treated zone. It is primarily broken down by soil micro-organisms.

TRICLOPYR

TRADE NAME: GARLON^R 3A, GARLON^R 4, and others.

Triclopyr is a broad-spectrum herbicide originally developed for control of vegetation along utility rights-of-way and on industrial sites. In forestry, it is labeled for site preparation and release. Methods of application include cut-surface treatments, foliar spray, and basal bark spray. Triclopyr is primarily absorbed by plant leaves and is readily moved throughout the plant. It affects plants by interfering with normal growth processes. In soil, triclopyr is not highly mobile. It is rapidly broken down by soil micro-organisms and ultraviolet light, persisting an average of 30-56 days depending on soils and weather. Its half life in water is about 10 hours at 72°F.

2,4-D AND 2,4-DP

TRADE NAME: WEED RHAP A-4D^R, Weedone^R 2,4-DP, Esteron^R 99, and others and as a major component of Tordon 101* and Tordon 101^R.

2,4-D and 2,4-DP are used to control broadleaf plants in food crops, pastures, lawns, rights-of-way, and range lands. They are used for brush and kudzu control in forestry. Labeled uses include site preparation and release. In the South, 2,4-D is not widely used in forestry work. Methods of application include cut-surface treatments, foliar spray, and basal bark sprays. Amine formulations are generally used for cut-surface treatments and esters for foliar spray and basal bark applications. 2,4-D and 2,4-DP are hormone-type growth regulators. They are absorbed by plant leaves, stems, and roots and moved throughout the plant. Accumulation occurs in growing tips. Salts of 2,4-D can move in sandy soils. Soil micro-organisms break them down in 1 to 4 weeks.

b. Manual Ground Tools

Tools used for manual ground application deliver herbicide in a variety of ways. Application of liquids include basal, soil-spot, foliar, and cut-surface treatments. Granules can be applied by hand or a hand-held spreader.

Liquid Application

Basal applications are used for release, precommercial thinning, and right-of-way maintenance, though some site preparation and balds maintenance work is also done this way. A spray gun or wand is used to direct the spray at a target stem. Two types of basal applications are used:

- Full basal treatments are applied to trees up to 5 inches in diameter. The lower 12 to 20 inches of the stem are wet with herbicide on all sides.
- Streamline treatments are applied to smaller juvenile stems. Herbicide is applied to one side of the stem in a 1.5- to 2-inch band.

Soil-spot applications are used for site-preparation and release (and some right-of-way) treatments. A soil-active herbicide is sprayed onto the soil in the treatment area. Three basic patterns of spray application are commonly used:

- Spot grid treatment is commonly used on sites with many stems per acre. Spots of herbicide are applied to the soil in a regular pattern.
- Individual stem treatment is applied by spraying the soil around unwanted plants.
- Spot-around treatments are made by spraying herbicide spots on the ground around the desired plant.

Foliar applications are usually used to release 3-year-old or younger stands from competition. Liquids are sprayed onto leaves of target plants in full leaf and growing.

- Directed foliar spray application is used to release young stands from competition that is less than 6 feet tall. Herbicide is generally applied to hit target vegetation but miss desired plants.

- Herbaceous weed control is done by applying herbicide directly over the top of all plants including desired plants to control competing vegetation. Herbicide is sprayed in a 4-5 foot circle or in a continuous band.

Cut-surface treatments are used to eliminate competing trees or control resprouting of stumps during site preparation, precommercial thinning, release, recreation, and balds maintenace operations. Three types of treatments are used:

- Tree injection, in which herbicide is placed directly within the wood of a tree by an injector, is most efficient on sites with sparsely distributed stems greater than 2 inches in diameter.

- Frill or girdle treatments involve cutting through the bark with an axe or hatchet to expose the cambium. The cut surface is then completely wet with herbicide. Girdles are formed by a completely encircling ring of cuts. Frilling generally results in a less complete ring of cuts.

- Cut-stump treatments are applied to stumps of any size to reduce sprouting. A sprayer is used to thoroughly wet the cambial area (about the outer 1 inch) of the stump.

Spray solutions are normally carried in backpack tanks, which hold between 1 and 5 gallons. These tanks have a diaphragm pump with a lever which allows the worker to pressurize the tank. Herbicide is applied to the target via a hand-held gun or wand attached to the tank by a flexible hose. Within the gun or wand mechanism is a valve system controlled by a trigger, which allows the worker to start or stop application of the chemical. Application is made as a continuous flow or as a predetermined volume of liquid per pull of the trigger. Depending on type of nozzle used in the gun or wand, a large-droplet spray or a continuous stream of liquid is delivered.

The purpose of the project determines the type of tool used. To fully cover foliage (broadcast application), a gun or wand which dispenses a continuous flow of chemical through a spray nozzle is commonly used. Should a directed spray be desired (selective treatment), a spotgun or wand and a stream nozzle are most commonly employed. When treating freshly cut stumps, a continuous stream of herbicide from a spotgun or wand is used to soak the cambial area of the stump.

Sprays can drift, while continuous streams can splash back off the target vegetation. Tank weight makes the worker more subject to tripping in uneven terrain. Improperly maintained equipment is likely to leak on the worker. The hose between the backpack and hand unit can snag on vegetation and break, causing a spill of chemical directly onto the worker.

Tree injectors are closed hollow tubes (liquid tanks) which are refilled at the top and deliver liquid through a valve at the bottom. The valve end of the injector has a 1 to 2 inch blade used to cut through tree bark to expose the cambium. The injector is jabbed into a tree, a lever or string (trigger) is pulled, and herbicide is delivered into the cut.

A second form of injector is a modified hatchet called a hypo-hatchet. The cutting edge is about 1 to 2 inches wide and a hose and valve system are added. The hose connects the hatchet with a container attached to the applicator's belt. Herbicide is discharged into the cut by gravity and a piston system each time the hatchet is used.

A combination of injection and spraying using an axe and hand-held sprayer is called hack-and-squirt. A narrow-bladed hatchet is used to cut the bark of the target tree and a squirt bottle (held in the other hand) is used to apply herbicide to the cut.

All injection methods are target specific and are useful where selectivity is desired. These tools are most efficient where target species are sparsely distributed and stems are larger than 2 inches in diameter.

Injecting trees is a labor-intensive activity, so worker fatigue and safety can become limiting. Injector nozzles clog with bark and wood chips and need to be cleaned frequently. Splash from injecting into cuts causes the tool to become coated with herbicide during the workday. The hypo-hatchet is a very sloppy tool if not carefully maintained. Moreover, workers can be exposed to spray during the cut stroke and when the tool is removed from the cut. Squirt bottles used in hack-and-squirt are difficult to maintain and leak after only limited use.

Granule Application

Granules are manually applied by hand or hand-held spreaders. Treatments can be either selective or broadcast.

- Broadcast treatments scatter herbicide granules in a relatively uniform pattern over the treated area.
- Selective treatments locate target and non-target vegetation and place the granules either near target plants (to reduce their growth), or away from a desirable plant (to release it as in spot-around).

To hand-spread granules, only a sack and personal protective equipment are needed. Wearing gloves, workers carry the herbicide in a sack and throw the granules onto the ground. Hand-held granule spreaders are generally fertilizer spreaders: hoppers with a crank-operated rotating disk attached below. Granules pass through a small opening in the hopper onto the disk and are thrown from it when the crank is turned.

Granules are most commonly applied for site preparation, release, or right-of-way maintenance. They pose less risk to workers than liquid herbicides since there is less exposure to the herbicide (appendix A).

Granules require rain to release them into the soil where they become active, but they are subject to surface runoff in heavy rainfall. Additionally, they can bounce on impact and often tend to roll to the bottom of a furrow. This localized accumulation of granules can result in uneven control of vegetation.

c. Mechanical Ground Tools

Many mechanical systems are available to apply herbicides. Units are available to mount on crawler or rubber-tired tractors, skidders, tree shearers, or truck beds.

Mechanical ground equipment is normally designed to broadcast granules or sprays. Risk of exposing the applicator to herbicide is less than for manual ground methods. In addition, fewer workers are required.

All mechanical ground tools are subject to site-related restrictions; slope, soil, and proximity to streams must be evaluated to determine tool suitability. These methods allow for large-area coverage in a relatively short time, but they are not target selective.

Liquid Application

Mechanical tools for dispensing liquid herbicides have some common features. All have a tank (generally 25-300 gallons), a pump, a delivery system which controls the flow of herbicide, and nozzles which produce large spray droplets. The shape of many parts and overall configuration of the tool vary greatly, based on economics and proposed use. Most sprayers are controlled by the driver of the machine, though some require an operator in addition to the driver. Sprayers are commonly mounted on crawler tractors for use in forestry settings, though rubber-wheeled tractors or skidders are sometimes used. For roadside maintenance, truck-mounted units are most common.

Fixed-position booms similar to those used for agriculture (20-foot-wide boom with as many as 21 nozzles mounted at uniform intervals) are sometimes used in forestry or right-of-way maintenance. It is, however, more common to see one or two clusters of "raindrop"-producing nozzles mounted on a short movable boom. A long boom (15 feet) has been developed for doing release work in heavily wooded areas. The boom is mounted vertically at the back of a crawler tractor with the nozzles broadcasting herbicide dow onto vegetation.

The most common application pattern for mechanical sprayers is broadcast spray in narrow or wide bands. Electric systems, however, allow operators to vary position of boom and placement of spray with a fair degree of accuracy. Electric boom-positioning controls are more common on units designed for roadside maintenance.

Granule Application

Granule spreaders are large, rugged units powered by the machine on which they are mounted or by an independent power source. The spreaders either throw or blow the pellets through a dispensing tube.

They are used primarily for site-preparation or release where broadcast application is appropriate. Granules tend to bounce and roll on impact, often rolling together in small depressions. This can cause spotty results or too much herbicide in one area.

d. Aerial Tools

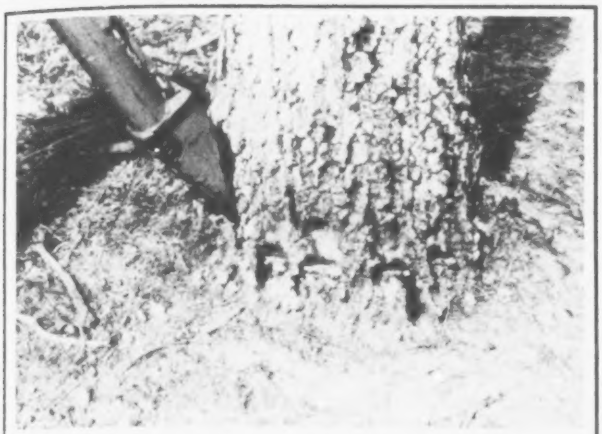
Application by helicopter is the only aerial method evaluated. Granules and liquids can be applied aerially. The herbicide tank or hopper is mounted outside the cabin, reducing pilot exposure to the chemical. Due to the large amount of herbicide which can be applied daily, the mixer/loader faces greater exposure risk than in a mechanical ground project. Aerial application requires very few workers.

Aerial methods are useful for site preparation, release, and right-of-way maintenance. Aerial delivery systems are most effective on larger areas. Due to buffer requirements and economics, aerial treatment is rarely practical for less than 20-acre blocks.

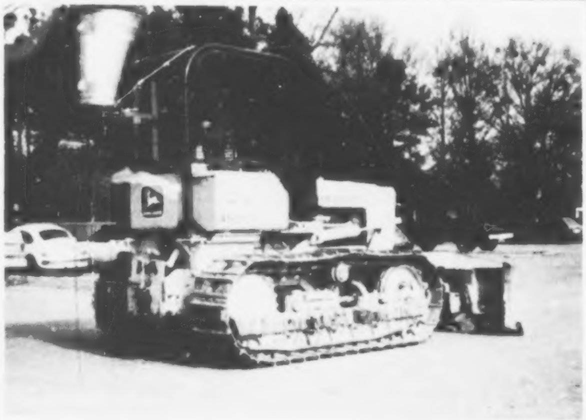
Drift is a primary concern during aerial operations. Uniformly large droplets and relatively heavy pellet weight sharply reduce drift. Care must be taken, however, to ensure proper safety standards.

Aerial operations are broadcast applications, and the pilot has limited ability to treat specific target plants. He can manipulate position and speed of his aircraft, can start or stop herbicide flow, and often has control of the flow rate of the herbicide. But these controls are rather inexact

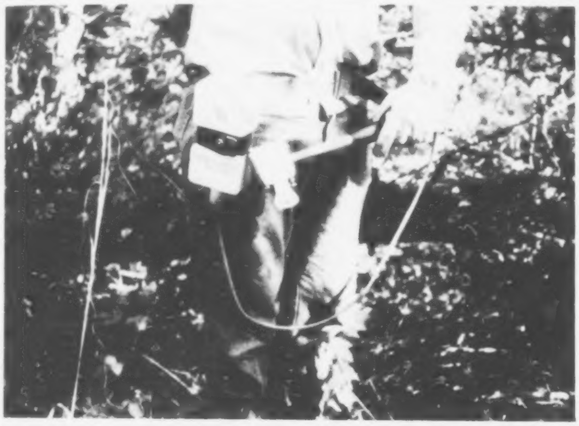
HERBICIDE TOOLS



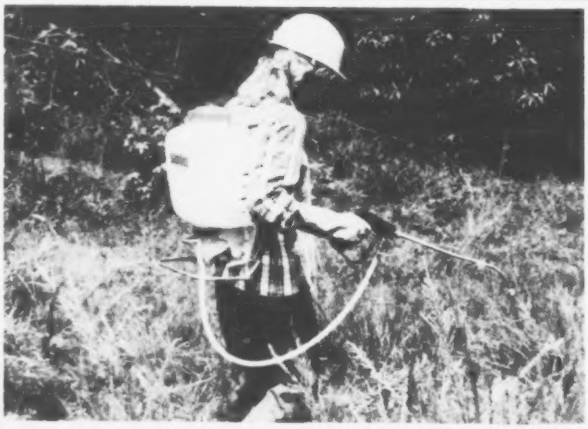
Injector



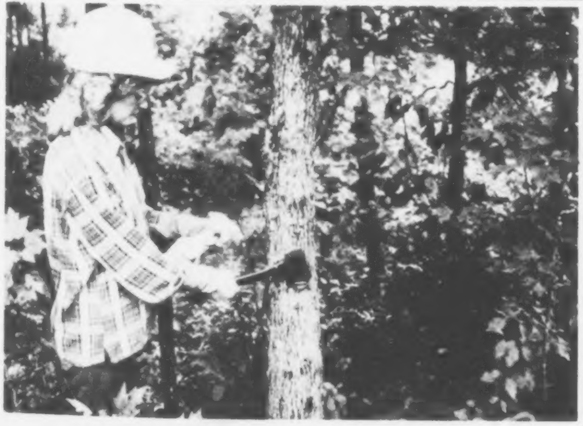
Granular spreader



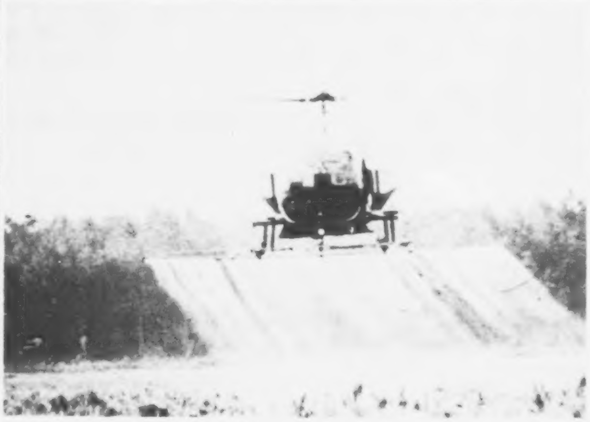
Hypo-hatchet



Backpack sprayer with spotgun attachment



Axe and sprayer



Helicopter spraying

when compared with manual ground applications. Selection of the proper herbicide is critical to the success of an aerial application project.

Liquid Application

Aerial systems for applying liquids are boom/nozzle systems such as the microfoil boom. The system generates streams of liquid which, in the wake of the boom, break into droplets as a result of air turbulence. Droplets formed in this manner are relatively large and uniform. Another system being tested (through-the-valve boom or TVB system) is also designed to generate large droplets. Booms are mounted in static air below and in front of the helicopter; but flow is controlled by the pilot. Herbicide tanks used in the Region contain a maximum of 100 gallons.

Granule Application

A specially designed spreader is suspended below the helicopter. Air flow through the mechanism distributes the granules in the helicopter's wake. The hopper and feed mechanism is outside the cabin but controlled by the pilot.

e. Herbicide Use Classification

Table II-1 is a classification of herbicide/method combinations. It assumes typical application rates and typical exposures (tables 4-4 through 4-6, appendix A). It also assumes that all mitigation measures described in this chapter are in place. Combinations of chemicals and application methods are classified as follows:

- Class A - Do not pose risk which would require mitigation in addition to those stated in chapter II (section E.2.c.).
- Class B - Pose human or wildlife health risk which requires additional mitigation, **OR** have soil-active half-lives (appendix A, table 4-9) exceeding 6 months.
- Class C - Pose human or wildlife health risk which requires additional mitigation, **AND** have soil-active half-lives (appendix A, table 4-9) exceeding 6 months.
- Class D - Pose a risk to human or wildlife health or to the environment which cannot be mitigated to an acceptable level of risk.

When additional mitigation is required, several options are available: select a different herbicide; reduce amount of herbicide applied per acre; shorten the workers' work day; change method of application; etc. Selection of additional protective measures is done during site-specific project analysis.

5. Biological Methods

Biological methods intentionally use living organisms to suppress, inhibit, control, or eliminate growth of herbaceous and woody vegetation. For the purpose of this EIS, only grazing by domestic livestock for mountain balds maintenance is evaluated as a viable biological control method.

Table II-1.--Classification of chemical/method combinations when used at typical rates and exposures (tables 4-4 through 4-6, appendix A)

Class[1]	A	B	C	D
Manual ground:				
Cut surface	DIC; GLY; IMZ; PIC; TRA	2,4-DA		
Basal stem	DES; KER; LIM; TRE; 2,4-DP	2,4-DE		
Soil spot	HEX	TEB		
Foliar spray	FOS; GLY; HEX; IMZ; KER; LIM; PIC; SMM; TRA; TRE	2,4-DA; 2,4-DE; 2,4-DP	TEB	
Mechanical ground	DES; DIC; FOS; GLY; HEX; IMZ; PIC; SMM; TRA; TRE; 2,4-DP	2,4-DA; 2,4-DE; TEB		
Aerial	DES; FOS; GLY; HEX; IMZ; KER; LIM; PIC; SMM; TRA; TRE; 2,4-DP	2,4-DA; 2,4-DE; TEB		

KEY:
2,4-DA = 2,4-D Amine
2,4-DE = 2,4-D Ester
DIC = Dicamba
DES = Diesel
FOS = Fosamine
GLY= Glyphosate
HEX = Hexazinone
IMZ = Imazapyr
KER = Kerosene
LIM = Limonene
PIC = Picloram
SMM = Sulfometuron Methyl
TEB = Tebuthiuron
TRA = Triclopyr Amine
TRE = Triclopyr Ester

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[1] Class is based on the analysis in the risk assessment (appendix A). ANY change from conditions evaluated in the risk assessment will affect proper placement of the chemical/method combination within the table. This table is intended for use in general forest or right-of-way conditions. Where threatened, endangered, proposed, or sensitive species are present, appropriateness of the chemical/method combination will be determined during the project environmental analysis.

Researchers are currently evaluating other potential methods of biological control. Some experimental methods show promise but are not yet operational for forestry. These methods include microbial and viral agents (biological herbicides); plant pathogens, insects, nematodes, genetics (natural adaptability and plant breeding); competition (interspecific); allelopathy (plants affecting other plants through chemical inhibitors); and biodegradable mulches. When any of these methods is determined to be successful at operational levels, it will be evaluated for use in the vegetation management program. Its use will then be coordinated through all applicable State and Federal programs and regulations.

On national forests, domestic livestock such as cattle, horses, sheep, and goats are in limited use as biological control methods primarily in the western United States. Little use has occurred in the East. The objective is vegetation control through prolonged grazing, not animal weight-gain. Numbers of livestock are managed so that grassy balds are maintained with little site damage.

Effectiveness of grazing for vegetation control depends on size of area, amount of control needed, types and amounts of herbaceous and woody species present, and feeding selectivity of animals used. For example, on an area where herbaceous species are to be controlled, cattle and horses may be appropriate because they are more likely to graze grasses, grass-like plants, and forbs. Where woody species are to be controlled, goats may be more appropriate because a higher component of their diet consists of woody browse species.

Desirable herbaceous and woody species are susceptible to overbrowsing and trampling. Moreover, risks of soil erosion and compaction are high from overgrazing. Conflicts with wildlife can also occur in areas with habitat limitations or restrictions (such as seasonal food shortages). Location of water sources, proper fencing or herding requirements, availability of livestock, and economics can also be limiting factors.

E. MANAGEMENT REQUIREMENTS AND MITIGATION MEASURES

This section describes management requirements and mitigation measures. Management requirements set direction on how resources are managed (such as timber stocking standards). Mitigation measures are actions necessary to lessen adverse impacts or to enhance beneficial effects (such as streamside protection). There are two groups:

General management requirements and mitigation measures apply to all methods.

Method-specific management requirements and mitigation measures pertain only to specific methods and are in addition to the general requirements and measures.

1. General Management Requirements and Mitigation Measures

The following general requirements and measures apply to all vegetation management methods. **Each forest may be more restrictive, but not less.**

a. Site-Specific Analysis

(1) Projects must have site-specific analysis in compliance with the National Environmental Policy Act (NEPA). This environmental analysis considers site-specific techniques, intensity of application methods, and potential environmental effects of any method considered. A reasonable range of alternatives, including one which does not use herbicides and a "no action" alternative, is examined.

Potential direct, indirect, and cumulative effects are evaluated. Effects to be considered include long-term soil productivity, water quality, air quality, visual quality, vegetation diversity, wildlife, fish, cultural resources, civil rights (including those of minorities and women), and threatened, endangered, proposed, and sensitive species.

The intent of this requirement is to ensure adequate environmental analysis. Congress and the Council on Environmental Quality have recognized the effectiveness of NEPA in developing environmental awareness and protecting the human environment. Monitoring is done through review of site-specific analyses and post-treatment evaluations.

(2) A biological evaluation of how a project may affect any species Federally listed as threatened, endangered, or proposed, or identified by the Forest Service as sensitive, is done as part of the site-specific environmental

analysis. This evaluation considers all available inventories of threatened, endangered, proposed, and sensitive species populations and their habitat for the proposed treatment area. When adequate population inventor information is unavailable, it must be collected when the site has high potential for occupancy by a threatened, endangered, proposed, or sensitive species. Appendix D identifies potential adverse effects from vegetation management by species. When adverse effects are projected, mitigation measures in this chapter and information in appendix D are used to prevent them.

Requirements and measures for actions affecting threatened, endangered, or proposed species are detailed in species recovery plans and FSH 2609.23R. Recovery plans have been prepared for the eastern cougar, southern bald eagle, American peregrine falcon, red-cockaded woodpecker, Virgini roundleaf birch, mountain golden heather, small whorled pogonia, gray bat, Indiana bat, Virginia big-eared bat, conasauga perch, slender chub, spotfin chub, smoky madtom, yellowfin madtom, noonday snail, birdwing pearly mussel, shiny pigtoe pearly mussel, Appalachian monkey-face pearly mussel, fine-rayed pigtoe pearly mussel, dromedary pearly mussel, yellow-blossom pearly mussel, green-blossom pearly mussel, and tan riffle shell pearly mussel. Chapters in FSH 2609.23R have been prepared for red-cockaded woodpecker and southern bald eagle. Requirements and measures for actions affecting sensitive species are detailed in Forest Land and Resource Management Plans.

If it is determined that the project may positively or negatively affect threatened, endangered, or proposed species, consultation is initiated with the Fish and Wildlife Service. If, during informal consultation, it is determined that the project is not likely to adversely affect listed species and the Fish and Wildlife Service so concurs in writing, consultation is terminated. However, if it is determined that the project is likely to adversely affect listed species, formal consultation is initiated. Figure D-1 outlines this process.

When the evaluation indicates that a project may have an adverse effect on a sensitive species or its habitat, appropriate State wildlife agencies, natural heritage commissions, and other cooperators or species authorities are contacted to identify coordination measures. These measures are directed towards ensuring species viability and preventing negative population trends that would result in Federal listing.

The intent of this requirement is to protect threatened, endangered, proposed, and sensitive species. Monitoring is done through review of site-specific analyses, onsite inspections, and post-treatment evaluations.

(3) Integrated Pest Management (IPM) principles are used during site-specific analysis. IPM is a decision-making and action process which includes biological, economic, and environmental evaluation of pest-host systems to manage pest populations.

IPM strategies involve a comprehensive systems approach to silvicultural, wildlife, fuel treatment, recreation and corridor management practices that emphasizes prevention of pest problems. These strategies consist of a range of practices that include prescribed fire, manual, mechanical, biological, and chemical tools that may be used alone or in combination. Risk rating systems and pest incidence surveys are used during site-specific analysis. Further IPM direction is provided in FSM 3400, FSH 3409.11, and Forest Land and Resource Management Plans.

The intent of this requirement is to ensure use of IPM during project planning. Monitoring is done through review of site-specific analyses, on-site inspections, and post-treatment evaluations.

(4) In each project, water quality is protected from nonpoint-source pollution through use of preventive "best management practices" (BMP's). Implementation of BMP's, monitoring and evaluation of their application and effectiveness, and adjustment of practices as needed are done to protect beneficial water uses.

BMP's are applied to all activities in all alternatives. Some BMP's required to protect water quality appear in this section as mitigation measures for soil and water. BMP's applied in projects may be more stringent and more effective in protecting water quality than those in this section, but not less. In each project, site-specific conditions must be assessed, and the BMP's needed to comply with State water quality management plans and pertinent Federal regulations must be employed.

The intent of this requirement is to protect water quality and assure compliance with State water quality laws. Monitoring is provided through evaluation of BMP application and analysis of water quality.

b. Timber Stand Improvement (TSI)

(5) For evenage timber management, methods that maintain stocking levels (stems per acre) and improve growth rates are used (table II-2).

Table II-2.--*Southern Region restocking standards: number of desirable stems per acre.

Forest Type	Lower Level	Target Level	Upper Level
Loblolly pine	300	500-700	900
Shortleaf pine	300	500-700	900
Longleaf pine	400	600-900	1,200
White pine	150	250-350	500
Virginia pine	300	500-700	900
Mixed pine-hardwood	300	400-600	900
Hardwoods (all species)	150	250-350	500

* Stocking levels shown are guides, and must be used in conjunction with professional judgment to determine restocking levels for a specific site.

(6) Pine stands receive release and weeding necessary to meet growth rates and stocking levels established in Forest Land and Resource Management Plans. Stands are considered for release when the desired seedlings are not free to grow, when competing growth threatens to overtop and compete directly for sunlight, moisture, and nutrients, or when competition results in less-than-average growth for comparable sites.

(7) Precommercial thinning of pine (usually done before age 10 to 15 years) is considered when stem density exceeds the upper level of restocking standards.

(8) Hardwood stands are generally not released. Clumps of competing stems are removed, however, where they may interfere with desired trees.

(9) Hardwood stands, where codominant trees of seedling (not sprout) origin are 25 feet or taller, are considered for precommercial thinning.

(10) Where a mixed pine/hardwood type is the management objective, release or precommercial thinning is designed to favor the best quality stems of desired species, which includes both pine and hardwood. Best quality includes consideration of origin, form, etc. Desired species are those that best achieve the Forest Land and Resource Management Plan objectives.

The purpose of requirements (5) through (10) is to achieve species composition and stand structures that reflect healthy, productive stand conditions. Knowledge gained through research and many years of management experience and contained in silvicultural guides have shown these measures to be effective. Monitoring is accomplished through periodic inventories.

c. Soil, Water, and Aquatic Life

(11) Channel stability of perennial and intermittent streams is protected by retaining all woody understory vegetation within at least 5 feet of the bank and by keeping slash accumulations out of the stream.

This measure is in addition to filter strips required on pages II-57 and II-60. It protects streams from excess channel erosion by preventing channel obstructions and maintaining living root systems on banks. Beasley (1979), Patric (1976), and Ursic (1975) show its importance in controlling channel erosion. Monitoring is accomplished through project plan reviews and onsite inspections.

d. Cultural Resources

(12) When any soil disturbing activity is planned, an archaeologist performs a field survey to locate cultural resource sites and assess their significance and protection needs. Sites meeting criteria for significance are nominated to the National Register of Historic Places. All archaeological reports (surveys, site evaluations, site nominations, site protection measures) are submitted to the State Historic Preservation Officer for review.

(13) If archaeological or historic resources are encountered during soil disturbing activities, work stops until an archaeologist evaluates the site's significance and the results and recommendations are reviewed by the State Historic Preservation Officer.

The intent of measures (12) and (13) is to identify and preserve significant cultural resources. They ensure compliance with Federal and State laws protecting cultural resources. Monitoring is done through onsite inspections and post-project evaluations.

e. Safety

(14) Safety equipment for Forest Service workers (such as hard hats, eye and ear protection, chaps, and fire retardant clothes) is worn as determined by a Job Hazard Analysis specified in the Health and Safety Code Handbook (FSH 6709.11). This analysis estimates risks to specific body parts and prescribes needed protection.

The purpose of this measure is to reduce the number and severity of accidents. Experience and analysis of past accidents allow for effective measures to prevent future occurrences. Monitoring is done through onsite inspections and reviews of accident reports.

f. Visual Quality

(15) Visual Quality Objectives (VQO's) are met by corridor maintenance, site preparation, timber stand and wildlife habitat improvement, bald and recreation site maintenance, and fuels treatment projects. These VQO's are:

Preservation allows only for change not caused by humans. Generally, no treatments are permitted.

Retention ensures that human activities are not evident to the casual forest visitor. Concern for visual quality is primary. Visual impacts should be eliminated during or promptly after treatment. Many treatments are allowed, but raking, piling, disking, and broadcast herbicide methods are usually not appropriate.

Partial Retention means that human activities may be evident but remain subordinate to the characteristic landscape. Concern for visual quality is high. Visual impacts should be eliminated at a minimum within the first year. Most treatments are allowed, but disking and broadcast herbicides are limited. In corridors, all methods and tools are available.

Modification indicates that human activity may dominate the characteristic landscape. Treatments should borrow established line, form, color, and texture so completely that visual characteristics are compatible with natural surroundings. All methods and tools are available for use.

Maximum Modification means that human activity may dominate the landscape, but should appear as a natural occurrence when viewed as background. All methods and tools are used, and at a greater intensity than in modification VQO.

(16) Treatments are scheduled as much as possible for the season that best meets VQO's. Rehabilitation and enhancement work may be needed to meet short-term VQO's. Visual diversity along active travelways (such as canopy layering, flowering trees) is protected from treatments where feasible and needed to meet VQO's. Tool selection and coordination requirements are determined by a site-specific project analysis.

Measures (15) and (16) ensure consideration of visual quality objectives established in Forest Land and Resource Management Plans. Experience shows that meeting established visual quality objectives is effective in protecting the visual resource. Monitoring is done through onsite inspections and post-treatment evaluations.

g. Wildlife

(17) Wildlife stand improvement (WSI) seeks to improve vegetation species composition in timber stands and to develop wildlife habitat areas for game and nongame species. A variety of woody and herbaceous species suited to site conditions and burning regime are maintained to assure year-round quality habitat. Exceptions that may reduce plant species variety include treatments to improve habitat for species such as red-cockaded woodpeckers.

(18) For understory species WSI, proper management allows full sunlight on 30 percent of the forest floor. For hardwood overstory WSI, thinning encourages full crown development, vigorous growth, and soft or hard mast production. When thinning stands older than 30 years, stems are favored which show positive indication of bearing soft or hard mast.

(19) During TSI, WSI, and site preparation, selected groups of overstory and understory vegetation are protected and managed to assure a variety of softmast, hardmast, and cover species. During site preparation, active and potential den trees are retained in clumps (at least 1/2 acre per 20 acres) if they are not provided in adjacent stands not suitable for timber production, inclusions, or streamside management zones. During TSI and WSI, all recognized den trees are protected. In addition, during TSI, WSI, and site preparation, an average of at least 2 standing dead snags are retained per acre, in the form of large hardwood trees (greater than 12 inches) when possible. Appropriate treatments are used to create snags where natural snags are lacking.

The intent of measures (17) through (19) is to provide a variety of wildlife and suitable habitat. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring is accomplished through review of project proposals, onsite inspections, and periodic inventories.

(20) When thinning or conducting site preparation, grapevine control is usually considered only in stands with site index of 60 or more. Generally, stands are treated only when grapevines exceed 40 stems per acre or occur in at least 5 percent of tree crowns. Based on site conditions, other considerations include retaining some existing arbors and felling trees of low commercial value to create additional arbors.

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The purpose of this measure is to protect softmast-producing wild grapes which are an important food source for black bear, ruffed grouse, and other species (Smith 1984). Monitoring is accomplished through review of project proposals, onsite inspections, and periodic inventories.

h. Corridors

(21) Each forest works with utility special-use permittees to establish vegetation management objectives (such as wildlife, watershed, recreation, visual quality) for location of new utility lines and maintenance of existing ones. These objectives determine maintenance techniques and strategies.

(22) Where feasible, low-growing shrubs and grasses are established and maintained along utility lines where wildlife and aesthetic objectives are dominant. This measure applies only to alternatives B, D, E, F, G, Modified D, and Modified E.

(23) Where feasible, permanent vegetation is established and maintained on the roadbed of intermittent service roads when they are closed, and on the cut and fill slopes of all roads.

(24) Where practical, native flowering species are established, maintained, and enhanced on intermittent service roads when they are closed and on cut and fill slopes of all roads. This measure applies only to alternatives B, D, E, F, G, Modified D, and Modified E.

(25) Vegetation along trails is treated to maintenance levels identified in the publication "Trails South." Priority is given to correcting unsafe conditions, preventing resource damage, and providing for intended recreation experience level.

Measures (21) through (25) balance considerations for special uses and other forest values, promote safe and efficient use of facilities and limit adverse visual and erosion effects. Experience shows that careful coordination between resources and special uses effectively allows compatible, concurrent use. Monitoring is done through project proposal reviews, periodic inspections, and maintenance plan reviews.

i. Bald Maintenance

(26) A detailed management and action plan is prepared for each bald to be maintained. It contains the following elements: inventory of existing and past boundaries; flora and fauna; history of past use; management objectives; and specific guides for types and timing of treatments to use, areas of vegetation to treat and protect, coordination with the public and other uses such as wildlife and recreation, and monitoring requirements.

(27) Species not native nor established by pioneer uses are not introduced on balds.

Measures (26) and (27) protect native species and unique features of mountaintop balds. Monitoring is done through project proposal reviews and periodic inspections.

j. Recreation Site Maintenance

(28) Specific procedures for vegetation management in recreation sites are established on each forest and included in the district operation and maintenance plan. These procedures include timing of treatments, target and non-target vegetation, coordination with visitor use, and monitoring requirements to ensure visitor safety and enjoyment.

This measure provides compatibility between vegetation management and use of recreation sites. Monitoring is done through periodic project reviews.

k. Review and Reporting Requirements

(29) Each national forest must include vegetation management in its management review process. At a minimum, reviews must evaluate adequacy of vegetation management mitigations and monitoring.

(30) Using existing reporting systems, each national forest must report implementation of its vegetation management program annually. Every 3 to 5 years, Regional Office staff must assess these reports to be sure that the vegetation management program in the Appalachians approximates the acre distribution of methods and tools estimated for the selected alternative.

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2. Method-Specific Management Requirements and Mitigation Measures

These requirements and measures are in addition to general requirements and measures in the preceding section.

a. Prescribed Fire

The following apply to alternatives that use prescribed fire. **Each forest may be more restrictive but not less.**

(1) A written site-specific plan for all prescribed burns is prepared by trained resource specialists and approved by the appropriate Forest Service line officer prior to project implementation. This plan includes description of treatment area, burn objectives, weather factors and fuel moisture conditions, and resource coordination requirements. Coordination requirements include provisions for public and worker safety, burn day notification of appropriate agencies and persons, smoke management to comply with air quality regulations and protect visibility in smoke-sensitive areas, protection of visual and sensitive features, as well as fireline placement, specific firing patterns, ignition methods, and mop-up and patrol procedures. A post-burn evaluation compares treatment results with plan objectives.

This requirement ensures thorough planning, well-defined objectives, and selection of appropriate mitigation measures. Experience shows that planning and evaluation effectively eliminate avoidable adverse effects. Monitoring is done through review of burn plans, onsite inspections, and post-burn evaluations.

Vegetation Protection

(2) Underburns in loblolly, shortleaf, pitch, and table mountain pine stands are not done until pines are 10 to 15 feet tall or 3 to 4 inches in diameter at ground level. In longleaf pine stands, burns can be used prior to height growth for brownspot disease control when root collars of grass stage seedlings are at least 0.3 to 0.5 inch in diameter. After height growth begins, burns can be used once seedlings are 3 to 5 feet tall.

(3) Underburns are not done in commercial pine-hardwood stands and inclusions until hardwood stems reach 5 to 6 inches in diameter at ground level. Only low intensity, dormant season fires with flame lengths of 2 feet or less are allowed.

(4) Underburns are not done in commercial hardwood-pine or hardwood stands and inclusions until hardwood stems reach 8 to 10 inches in diameter at ground level. Only low intensity, dormant season backing fires with flame lengths of 2 feet or less are allowed. Underburns to improve wildlife habitat occur only if habitat is limiting or threatens species viability.

(5) Underburns are not done in commercial white or Virginia pine stands until they have formed a thick, corky bark. Only low intensity, dormant season backing fires with flame lengths of 2 feet or less are allowed.

(6) Underburns are not done in commercial spruce-fir stands.

Measures (2) through (6) protect trees from damage by fire. Chen, Hodgkins, and Watson (1975), Goebel, Brender, and Cooper (1967), Johnson (1982), Komarek (1974), and Wade (1986) show their effectiveness in limiting injury and mortality. Effectiveness is also based on principles of wildife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring is done in project proposal reviews and in post-burn evaluations.

Soil and Water Protection

(7) Slash burns are done so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. Steps taken to limit soil heating include use of backing fires on steep slopes, scattering slash piles, and burning heavy fuel pockets separately. This measure applies only to alternatives B, D, E, F, Modified D, and Modified E.

(8) On severely eroded forest soils, any area with an average litter-duff depth of less than 1/2 inch is not burned. This measure applies only to alternatives B, D, E, F, Modified D, and Modified E.

(9) Growing season underburns are not allowed on the same site more than twice in succession without an intervening dormant season burn. This measure applies only to alternatives B, D, E, F, Modified D, and Modified E.

Measures (7) through (9) protect soil productivity. Appendix B and the analysis in chapter IV found these measures effective in preventing excessive losses of soil biota, organic matter, and nutrients. Monitoring includes project proposal reviews and post-burn evaluations.

(10) Where needed to prevent erosion, water diversions are installed on firelines during their construction, and the firelines are revegetated promptly after the burn.

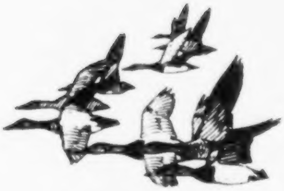
(11) Firelines which expose mineral soil are not located in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps, unless tying into lakes, streams, or wetlands as firebreaks at designated points with minimal soil disturbance. Low-intensity fires with less than 2 foot flame lengths may be allowed to back into the strip along water bodies, as long as they do not

kill trees and shrubs that shade the stream. The strip's width in feet is at least 30 plus 1.5 times the percent slope.

Measures (10) and (11) limit erosion and siltation. Cushwa, Hopkins, and McGinnes (1971) found that prevention of fireline erosion effectively eliminates sedimentation from many burns. Swift (1986) showed the above filter strip to be effective in trapping soil eroded by unconcentrated surface runoff. Monitoring is done in project proposal reviews, during burns, and in post-burn evaluations.

Wetland Protection

(12) When wetlands need to be protected from fire, firelines are used around them only when the water table is so low that the prescribed fire might otherwise damage wetland vegetation or organic matter. Where practical, previous firelines are reused, and firelines must cause minimal soil disturbance.



(13) If a fireline is required next to a wetland, it is not located in the transition zone between upland and wetland vegetation except to tie into a natural firebreak, and it must cause as little soil disturbance as practicable.

The purpose of measures (12) and (13) is to prevent fireline scars which are often slow to heal in wetlands. Additionally, integrity of water flow in wetlands is protected. Monitoring is accomplished through project proposal reviews and post-burn evaluations.

Air Quality Protection

(14) Smoke management guidelines are used to reduce smoke emissions. When feasible, backing and flanking fires are used instead of heading fires, and burning is done when duff and large fuels are moist and small fuels are dry. Slash piles are not burned unless relatively free of soil. All burns are completed during the active burning period and mopped up as soon as practical after completion.

(15) Smoke management guidelines are also used to enhance smoke dispersion. Burning is done when the atmosphere is thermally neutral to slightly unstable, not during pollution alerts, stagnant or humid weather, or inversions. Burning is done only when:

-- air quality or visibility standards in smoke-sensitive areas (see "A Guide for Prescribed Fire in Southern Forests" (Wade and Lunsford 1989) pages 31-32) such as highways, airports, populated areas, and Class I areas will not be violated by smoke from the fire.

-- atmospheric mixing height is at least 1,650 feet, transport windspeed is at least 9 mph, and background visibility downwind is at least 5 miles.

The intent of measures (14 and (15) is to comply with air quality regulations and protect health and safety. Sandburg and Ward (1981), USDA Forest Service (1976), and Wade and Lunsford (1989) showed that such measures are effective in limiting smoke emissions and effects. Monitoring includes project plan reviews, pre-burn weather evaluations, and during-burn inspections.

Wildlife Protection

(16) Generally, underburns are not scheduled during the nesting season to avoid disrupting reproductive activities. Forest managers may, however, use burns to meet specific objectives, such as protecting threatened and endangered species (e.g. red-cockaded woodpecker), reestablishing natural ecosystems, controlling brownspot disease and promoting longleaf height growth, and site preparation. Burns are planned and executed to avoid damage to habitat of any threatened, endangered, proposed, or sensitive species (such as destruction of bald eagle nest trees).

This measure protects valued habitats and minimizes wildlife reproduction disruptions. Effectiveness is based on principles of wildlife management and habitat requirements as described in FSH 2609.23R, FSH 2609.13, and general wildlife management texts such as Peek (1986). Monitoring occurs in project plan reviews and post-burn evaluations.

Bald Maintenance

(17) Except for alternative H, prescribed fire is not used more frequently than every 3 years except when needed to establish grasses or control encroachment by woody species.

(18) Firelines are plowed only when needed and are located at least 30 feet outside bald perimeters. Foam or wet lines only may be used for interior holding lines.

Measures (17) and (18) protect native vegetation and soils on mountaintop balds. Monitoring is done through project plan reviews and post-burn evaluations.

Safety

(19) Prescribed fires are conducted under the direct supervision of a burning boss with fire behavior expertise consistent with the project's complexity. All workers must meet health, physical and training requirements in FSM 5140, and use protective clothing and equipment.

This measure protects worker and public safety during prescribed burning. Monitoring occurs in project proposal reviews, onsite spections, and post-burn evaluations.

General Resource Protection

(20) Critical values of the Keetch-Byram Drought Code (Cumulative Severity Index) are developed for all major vegetation-soil-landform types on which prescribed fires are conducted. Burning is allowed only on days when the Drought Code is less than this critical value.

This measure protects vegetation and soil from damage caused by burning during times of moisture deficiency. The Drought Code reflects the soil moisture deficit and potential fire severity. Experience has shown this measure to protect resources when used with other mitigation measures listed in this section. Monitoring is done in project proposal reviews, during burns, and in post-burn evaluations.

b. Mechanical Method

The following apply to alternatives that use mechanical methods. **Each forest may be more restrictive but not less.**

Soil and Water Protection

(1) Prompt revegetation is done if treatments leave insufficient ground cover to control erosion by the end of the first growing season.

(2) Only mowing, chopping, shearing, ripping, and scarifying are used on sustained slopes over 15 percent. No mechanical equipment is used for vegetation management on sustained slopes over 35 percent.

(3) Mechanical site preparation is not done on sustained slopes over 20 percent with erodible or failure-prone soils.

(4) To limit soil compaction, no mechanical equipment is used on plastic soils when the water table is within 12 inches of the surface, or when soil moisture exceeds the plastic limit. Soil moisture exceeds the plastic limit if the soil can be rolled to pencil size without breaking or crumbling.

(5) Mechanical equipment is operated so that furrows and soil indentations are aligned on the contour (with grades of furrows and indentations kept under 5 percent).

(6) Windrows and piles are spaced no more than 200 feet apart to limit soil exposure, soil compaction, and nutrient loss from piling and raking. Windrows are aligned on the contour.

(7) When piling, at least 80 percent of the area must retain some ground cover of litter and duff, and soil must not be displaced into piles or windrows.

(8) Mechanical equipment is not allowed in any defined stream channel except to cross at designated points, and may not expose more than 10 percent mineral soil in filter strips along lakes, perennial or intermittent springs and streams, wetlands, or water-source seeps. The strip's width in feet is at least 30 plus 1.5 times the percent slope. Soil and debris are not deposited in lakes, streams, wetlands, springs, or seeps.

Measures (1) through (8) minimize soil damage and sedimentation. Beasley, Granillo, and Zillmer (1986), Blackburn, Wood, and DeHaven (1986), Gent, Ballard, and Hassan (1983), Gent and others (1984), and Swift (1986) found these measures to be effective and necessary to control soil damage and loss. Monitoring is done in project plan reviews and post-project evaluations.

Corridors

(9) All trails, roads, ditches, and other improvements in the project area are kept free of logs, slash, and debris. Any road, trail, ditch, or other improvement damaged by operations is promptly repaired.

This measure protects improvements. Experience shows that preventive measures or prompt repair effectively minimizes damages. Monitoring is done in project plan reviews and post-project evaluations.

Bald Maintenance

(10) Scarifying, ripping, raking, piling, and disking are not used on balds except to restore them through seedbed preparation.

This measure protects soils and native vegetation on mountaintop balds. Monitoring is done in project plan reviews and post-project evaluations.

Safety

(11) Forest Service equipment operators must demonstrate proficiency with the equipment and be licensed to operate it. A helper must direct the operator where safety is compromised by terrain or limited sight distance.

The intent of this measure is to protect worker and public safety. Monitoring occurs in periodic inspections and licensing.

c. Herbicide Method

The following apply to alternatives that use herbicides. **Each forest may be more restrictive but not less.**

(1) Herbicides are applied according to labeling information and the site-specific analysis done for projects. This labeling and analysis are used to choose the herbicide, rate, and application method for the site conditions and species to be controlled. They are also used to select measures to protect human and wildlife health, non-target vegetation, water, soil, and threatened, endangered, proposed, and sensitive species. Site conditions may require stricter constraints than those on the label, but labeling standards are never relaxed.

Choice of Herbicide

(2) Only herbicide formulations (active and inert ingredients) and additives registered by EPA and approved by the Forest Service for use on national forests are applied.

(3) Herbicides and application methods are chosen to minimize risk to human and wildlife health and the environment. No class B, C, or D chemical (table II-1) may be used on any project, except with Regional Forester

approval. Approval will be granted only if a site-specific analysis shows that no other treatment would be effective and that all adverse health and environmental effects will be fully mitigated. Whenever possible and effective, class 4 or 5 mineral oil is used in place of diesel oil in mixtures for application. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E.

Application Rate

(4) Herbicides are applied at the lowest rate effective in meeting project objectives and according to guidelines for protecting human (NRC 1983) and wildlife health (EPA 1986a). Application rate and work time must not exceed typical levels (appendix A, tables 4-4 to 4-6) unless a supplementary risk assessment shows that proposed rates do not increase risk to human or wildlife health or the environment beyond standards discussed in Chapter IV. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E. Typical application rates (lb/ac) of active ingredient are:

	2,4-D/a	2,4-D/e	2,4-DP	DICAMBA	FOSAMINE	GLYPHOS	HEXAZ	IMAZAPYR
AL	2.0	2.5	3.0		6.0	1.5	1.5	0.75
AG							1.7	
ML	2.5	4.0	4.0	2.0	7.8	1.5	1.7	0.75
MG							1.7	
HG							1.7	
HF	2.0	2.0	1.0	2.0		1.0	0.5	0.75
HB		1.7	1.2					
HS							1.7	
HC	2.0			1.5		1.3		0.75

	FUEL OIL	LIMONENE	PICLORAM	SULFOMET	TEBUT	TRICLOPYR/a	TRICLOPYR/e
AL	0.5	0.9	0.5	0.13	1.0	3.0	4.0
AG					1.0		
ML	2.0	0.9	0.7	0.17	1.0	4.0	4.0
MG					1.0		
HG							
HF	1.5	0.9	0.4	0.06	4.0	1.4	1.0
HB	1.0	0.9					1.9
HS					4.0		
HC			0.3				

KEY: AL = aerial liquid treatment
AG = aerial granular treatment
ML = mechanical liquid treatment
MG = mechanical granular treatment
HG = manual (hand) granular treatment
HF = manual foliar broadcast treatment
HB = manual basal treatment
HS = manual soil-spot treatment
HC = manual cut-surface treatment

GLYPHOS = glyphosate
HEXAZ = hexazinone
SULFOMET = sulfometuron methyl
TEBUT = tebuthiuron
/a = amine formulation
/e = ester formulation

Application Method & Public Safety

(5) Public safety during such uses as viewing, hiking, berry picking, and fuelwood gathering is a priority concern. Method and timing of application are chosen to achieve project objectives while minilizing effects on non-target vegetation and other environmental elements. Selective treatment is preferred over broadcast treatment. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E. Application methods from most to least selective are:

1) Cut surface treatments
2) Basal stem treatments
3) Directed foliar treatments
4) Soil spot (spot around) treatments
5) Soil spot (spot grid) treatments
6) Manual granular treatments
7) Manual/mechanical broadcast treatments
8) Helicopter treatments

Prescribed Burning of Treated Areas

(6) Areas are not prescribed burned for at least 30 days after herbicide treatment. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E.

Measures (1) through (6) ensure legal compliance and mandate further steps to improve safety and effectiveness of treatment. The Risk Assessment (appendix A) shows that screening herbicides, reducing application rates, and using selective application methods lowers health and environmental risk. Experience has shown 30 days to be the minimum time for herbicides to work and fuels to cure. Monitoring is done by reviewing purchase orders, contract specifications, project reports, and annual herbicide-use reports.

Drift Control

(7) Weather is monitored and the project is suspended if temperature, humidity, or wind become unfavorable as follows:

	Temperatures Higher Than	Humidity Less Than	Wind (at Target) Greater Than
Ground:			
Hand (cut surface)	N.A.	N.A.	N.A.
Hand (other)	98F	20%	15 mph
Mechanical (liquid)	95F	30%	10 mph
Mechanical (granular)	N.A.	N.A.	10 mph
Aerial: Liquid	90F	50%	5 mph
Granular	N.A.	N.A.	8 mph

(8) Nozzles that produce large droplets or streams of herbicide are used. Nozzles that produce fine droplets are used only for hand treatment where distance from nozzle to target does not exceed 8 feet.

Measures (7) and (8) reduce drift of herbicides offsite. Yates, Akisson, and Bayer (1978) demonstrated their effectiveness. Monitoring occurs via weather observation and supervision.

Supervision and Training

(9) A certified pesticide applicator supervises each Forest Service application crew and trains crew members in personal safety, proper handling and application of herbicides, and proper disposal of empty containers.

(10) Each Contracting Officer's Representative (COR), who must ensure compliance on contracted herbicide projects, is a certified pesticide applicator. Contract inspectors are trained in herbicide use, handling, and application.

Measures (9) and (10) promote compliance with labeling instructions and reduce risk of accidents. Effectiveness and monitoring are provided by the Pesticide Applicators Training and Certification program, where a minimum test score of 70 percent is required for certification.

Protection of Workers

(11) Forest Service workers who handle herbicides must wear a long-sleeved shirt and long pants made of tightly woven cloth that must be cleaned daily. They must wear a hard hat with plastic liner, waterproofed boots and gloves, and other safety clothing and equipment required by labeling. They must bring a change of clothes to the field in case their clothes become contaminated.

(12) Each Forest Service crew must take soap, wash water separate from drinking water, eyewash bottles, and first aid equipment to the field.

(13) Contractors ensure that their workers use proper protective clothing and safety equipment required by labeling for the herbicide and application method. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E.

(14) Workers must not walk through areas treated by broadcast foliar methods on the day of application. This measure applies only to alternatives B, D, E, G, Modified G, and Modified E.

(15) Supervisors must ensure that monitoring is adequate to prevent adverse health effects. Workers displaying unusual sensitivity to the herbicide in use are medically evaluated and, if tested as sensitive to the herbicide in use, are reassigned to other activities. Female workers will not be used in backpack spray operations using tebuthiuron and 2,4-D.

Measures (11) through (15) reduce worker exposure to herbicides. Lavy, Mattice, and Norris (1984), Webster and Maibach (1985), and Yi-Lan and others (1984) demonstrate their effectiveness. Monitoring is done through supervision and review of accident reports.

Protection of the General Public and Private Land

(16) Notice signs (FSH 7109.11) are clearly posted, with special care taken in areas of anticipated visitor use. People living within one-fourth mile of an area to be treated aerially are notified during project planning and shortly before treatment.

(17) No herbicide is broadcast within 100 feet of private land or 300 feet of a private residence, unless the landowner agrees to closer treatment. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E.

(18) No herbicide is aerially applied within 200 horizontal feet of an open road or a designated trail. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives D, G, H, and Modified D.

Measures (16) through (18) reduce public exposure to herbicides. Monitoring occurs during project plan reviews, onsite inspections, and post-project evaluations.

Protection of Non-Target Vegetation

(19) No soil-active herbicide is applied within 30 feet of the drip line of non-target vegetation (e.g., den trees, hardwood inclusions, adjacent stands) within or next to the treated area. Side pruning is allowed, but movement of herbicide to the root systems of non-target plants must be avoided. Buffers are clearly marked before treatment so applicators can easily see and avoid them. This measure applies only to alternatives B, D, E, G, Modified D, and Modified E.

This measure protects non-target plants in and next to treated areas. Appendices A and C show that buffers sharply reduce offsite movement. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Protection of Threatened, Endangered, Proposed, and Sensitive Species

(20) 2,4-D, 2,4-DP, and triclopyr are not aerially applied within 300 feet, nor ground-applied within 60 feet, of known occupied gray, Virginia big-eared, or Indiana bat habitat. The same buffers are used with 2,4-D around habitat of these sensitive animals: star-nosed mole, old-field mouse, masked shrew, southeastern shrew, southern pygmy shrew, long-tail shrew, southern water shrew, southern rock vole, red-backed vole, Keen's myotis eastern small-footed bat, and Rafinesque's big-eared bat. The same buffers are used with any formulation containing kerosene or diesel oil around habitat of any threatened, endangered, proposed, or sensitive bird during its nesting season. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

(21) No herbicide is aerially applied within 300 feet, nor ground-applied within 60 feet, of any known threatened, endangered, proposed, or sensitive plant. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (20) and (21) protect these species from toxic effects as predicted by the Risk Assessment (appendix A). They are consistent with proposed EPA and Fish and Wildlife Service restrictions on use of certain herbicides. If EPA, FWS, State, or other Federal agencies require stricter standards for any herbicide in the future, the Forest Service will adopt them. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Protection of Water and Soil

(22) Application equipment, empty herbicide containers, clothes worn during treatment, and skin are not cleaned in open water or wells. Mixing and cleaning water must come from a public water supply and be transported in separate labeled containers.

(23) Aquifers and public water sources are identified and protected by consulting with States to ensure compliance with their ground water protection strategies.

(24) No herbicide is broadcast on rock outcrops or sinkholes. No herbicide with a half-life longer than 3 months is applied on slopes over 45 percent, erodible soils, or aquifer recharge zones. Such areas are clearly marked before treatment so applicators can easily see and avoid them.

(25) No herbicide is aerially applied within 200 horizontal feet, nor ground-applied within 30 horizontal feet, of lakes, wetlands, or perennial or intermittent springs and streams. No herbicide is applied within 100 horizontal feet of any public or domestic water source. Selective treatments (which require added site-specific analysis and use of aquatic-labeled herbicides) may occur within these buffers only to prevent significant environmental damage such as noxious weed infestations. Buffers are clearly marked before treatment so applicators can easily see and avoid them.

Measures (22) through (25) reduce risk of surface and ground water pollution and soil erosion. Appendices A and C show that buffers sharply reduce offsite herbicide movement. Monitoring is done through project plan reviews, onsite inspections, and post-project evaluations.

Aerial Application Operations Plan

(26) Each aerial herbicide application project must have an operations plan approved by the forest's air safety officer who must ensure that: (a) adequate precautions are taken to protect the crew, including equipment certification and hazard identification; (b) areas to be aerially treated are clearly marked; and (c) methods used to avoid buffers and other sensitive areas are safe and effective. This measure applies only to alternatives D, G, H, and Modified D.

This measure provides for crew safety and protection of non-target areas. Monitoring occurs through project plan reviews, onsite inspections, and post-project evaluations.

Control of Spills

(27) During transport, herbicides, additives, and application equipment are secured to prevent tipping or excess jarring and are carried in a part of the vehicle totally isolated from people, food, clothing, livestock feed, and seed.

(28) Only the amount of herbicide needed for the day's use is brought to the site. At day's end, all leftover herbicide is returned to storage.

(29) Herbicide mixing, loading, or cleaning areas in the field are not located within 200 feet of private land, open water or wells, or other sensitive areas.

(30) During use, equipment to store, transport, mix, or apply herbicides is inspected daily for leaks.

(31) Containers are reused only for their designated purpose. Empty herbicide containers are disposed of according to 40 CFR 165.9 Group I & II Containers.

(32) Accident preplanning is done in each site-specific analysis. Emergency spill plans (FSM 2109.12, chapter 30)

are prepared. In the unlikely event of a spill, the spill is quickly contained and cleaned up, and appropriate agencies and persons are promptly notified.

Measures (27) through (32) reduce risk of accidental contamination of humans or the environment by concentrated amounts of herbicide. Experience has shown them to be effective in reducing spillage and contamination. Monitoring occurs through supervision and incident report reviews.

d. Biological Method

The following applies to alternatives that use grazing as a biological method on balds. **Each forest may be more restrictive but not less.**

(1) A site-specific analysis determines how livestock are managed to limit soil compaction, water contamination, and damage to riparian vegetation and streambanks.

(2) Livestock may not expose mineral soil or displace soil by trampling on more than 10 percent of the area.

(3) Combined forage use by wildlife and livestock may not exceed 70 percent of total forage production. This allows 45 percent utilization of grasses and forbs for livestock and 25 percent for wildlife.

(4) When restoring balds, grazing is deferred until forage is firmly reestablished and adequate to control erosion.

Measures (1) through (4) protect site values such as soil, water, and desirable vegetation when grazing is used as a biological control. Blackburn (1984) and Patric and Helvey (1986) showed that such controls reduce grazing damage to soil and water. Monitoring is done through project plan reviews and periodic on-site evaluations.

e. Manual Method

The following apply to alternatives that use manual methods. **Each forest may be more restrictive but not less.**

Safety

(1) Forest Service chain saw operators must be periodically certified and demonstrate proficiency with chain saws.

(2) Forest Service workers must comply with dress and safety standards specified in the Health and Safety Code Handbook (FSH 6709.11).

The intent of measures (1) and (2) is to protect worker and public safety. Monitoring occurs in periodic inspections and recertification.

F. COMPARISON OF ALTERNATIVES WITH THE ISSUES

Issues (chapter I) represent expressions of concern by the public and Forest Service and employees, including management. These issues are the foundation for alternatives discussed earlier in this chapter. In this section, we compare the alternatives to see how they respond to the issues (table II-3).

Issues contain many values and are neither positive nor negative. Actually, issues express multiple concerns and desires, many of which are opposed to each other. Because of this aspect of issues, every alternative responds to each issue to some degree.

Major changes are expected when each alternative is compared with alternative A, the "no action" alternative (table II-3). Each issue is paraphrased in the following text, and the measure of comparison used in table II-3 is stated.

Herbicides: The principal concern is that non-target organisms, such as people, wildlife, or plants might be accidentally affected. There is also a fear of unknown long-term effects, particularly human health effects. Some people favor using herbicides and aerial application if adequate controls are maintained. Some also believe that aerial application is a necessity for treatment of corridors in steep inaccessible terrain. The measures of comparison are acres and selectivity of treatments, use of mitigations to reduce risks, and availability of aerial application.

Mechanical: Many people feel that mechanical treatments should be used to provide more employment and that they have fewer negative effects than herbicides or prescribed fire. Some people suspect that mechanical treatments have significant effects on water quality, fisheries, soil productivity, aesthetics and worker safety. Comparisons are based on acres and intensity of mechanical treatments.

Communication: This unique issue has only an indirect relationship to vegetation management activities. Responsiveness to this issue does not depend upon alternatives; therefore it is not in the comparison table. This environmental impact statement is an educational tool, and in part, addresses the communication issue. Many of the when, why, and where questions about vegetation management are discussed. Public participation in this process has been a hallmark, and the EIS mandates several processes in the future to continue a high level of participation.

Fire: Many people see prescribed fire as part of a "natural" system and as essential to provide for fuel reduction, wildlife habitat and diversity of plants and animals. Major concerns are about smoke management and potential adverse effects on hardwoods. Comparison measures are availability of fire for fuel and habitat treatments and timing, frequency, and intensity.

Table II-3.--Comparison of alternatives with issues

ALTERNATIVE	**ISSUES** Herbicides	Mechanical
Comparison Measure	Acres, selectivity, mitigations, availability of aerial application.	Acres, intensity.
A (No Action)	No herbicides are available.	No mechanical treatments are allowed.
B	Acres treated are 75% less than current. Tools are very selective. Extra mitigations apply. Aerial is not available.	Acres treated are half of current. Only low intensity tools are allowed.
C (Current)	Herbicide use is about 19% of the vegetation management program. Selective and broadcast tools are used. Only current mitigations apply. Aerial is not available.	Low to high intensity tools are available.
D (Draft Preferred)	Acres treated are 39% more than current. Selective and broadcast tools are used with selective favored. Extra mitigations apply. Aerial occurs on 900 ac/yr.	Acres treated are 21% less than current. Only low to moderate intensity tools are available.
MODIFIED D (Final Preferred)	Acres treated are 20% more than current. Selective and broadcast tools are used with selective much favored. Extra mitigations apply. Aerial occurs on 400 ac/yr.	Acres treated are similar to current. Only low to moderate intensity tools are available.
E	Acres treated are half of current. Selective and broadcast tools are available with selective favored. Extra mitigations apply. Aerial is not available.	Acres treated are 17% more than current. Only low to moderate intensity tools are available.
MODIFIED E	Acres treated are 69% less than current. Selective and broadcast tools are used with selective much favored. Extra mitigations apply. Aerial is not available.	Acres treated are similar to current. Only low to moderate intensity tools are available.
F	No herbicides are allowed.	Acres treated are 20% more than current. Only low to moderate intensity tools are available.
G	Acres treated are 53% more than current. Selective and broadcast tools are available. Extra mitigations apply. Aerial occurs on 2,100 ac/yr.	Acres treated are 12% more than current. Only low to moderate intensity tools are available.
H	Acres treated are double current. Selective and broadcast tools are available with broadcast favored. Only current mitigations apply. Aerial occurs on 8,700 ac/yr.	Acres treated are 9% less than current. Moderate to high intensity tools are favored.

Table II-3.—Comparison of alternatives with issues

ALTERNATIVE	ISSUES	
	Balance of Resources	Prescribed Fire
Comparison Measure	Output mix, timber-related treatments.	Availability, timing, frequency, and and intensity.
A (No Action)	Strongly favors outputs which occur without vegetation manipulation. Favors non-market. No treatments allowed for timber management.	Not available for use.
B	Favors non-market outputs. Market outputs are managed only to prevent resource damage. About 22 percent of vegetation management activities are for timber outputs.	Only about half the current acres are treated. All burns are low-intensity and less frequent.
C (Current)	Favors recreation (including wilderness), wildlife and timber (both market and nonmarket). About 40 percent of vegetation management activities are for timber outputs.	Low to high intensity burns are available and represent about 1/3 of the entire vegetation management program.
D (Draft Preferred)	Favors recreation (including wilderness), wildlife and timber (both market and nonmarket). About 40 percent of vegetation management activities are for timber outputs.	Acres treated, frequency and timing are similar to current. Only low to moderate intensity burns are available.
MODIFIED D (Final (Preferred)	Favors recreation (including wilderness), wildlife and timber (both market and nonmarket). About 40 percent of vegetation management activities are for timber outputs.	Acres treated. frequency amd timing are similar to current. Only low to moderate intensity burns are available.
E	Similar to current but some outputs may slightly decrease. Overall lower intensity treatments improve non-market outputs slightly. About 43 percent of vegetation management activities are for timber outputs.	About 30 percent fewer acres than current are treated. Only low to moderate intensity burns are available.
MODIFIED E	Similar to current but some outputs may slightly decrease. Overall lower intensity treatments improve non-market outputs slightly. About 40 percent of vegetation management activities are for timber outputs.	About 25 percent fewer acres than current are treated. Only low to moderate intensity burns are available.
F	Favors recreation (including wilderness), wildlife and timber outputs (both market and non-market). About 40 percent of vegetation management activities are for timber outputs.	Acres treated, frequency and timing are similar to current. Only low to moderate intensity burns are available.
G	Favors recreation (including wilderness), wildlife and timber outputs (both market and non-market). About 49 percent (though about same acres as current) of vegetation management activities are for timber outputs.	Not available for use.
H	Favors market outputs, especially timber. About 41 percent (though 35 percent more acres than current) of vegetation management activities are for timber outputs.	Low to high intensity burns are available and represent about 35 percent of the entire vegetation management program.

Balance of Resources: Concern is about the mix of resource outputs from national forests. It is believed that the principal use of vegetation management is for the benefit timber. People also suspect that an increase in market outputs like timber or an increase in non-market outputs such as aesthetics would necessarily be at the expense of the other. The measures of comparison are changes in outpu mix and level of vegetation management activity devoted to timber.

G. COMPARISON OF ENVIRONMENTAL EFFECTS

Every alternative has the potential to cause environmental effects. Environmental effects are analyzed in chapter IV. Ways to limit or control these effects are the management requirements and mitigation measures discussed earlier in this chapter. Because each alternative represents a different way to accomplish vegetation management work, effects will also differ.

Makeup of Alternatives

Kinds of effects and their severity or seriousness are determined by several factors:

- Which methods and tools are used?
- How many acres are treated?
- What intensity and frequency of treatments are applied?

Before reading the evaluation of environmental effects in chapter IV or looking at the comparison of effects between alternatives in table II-8, readers should become familiar with how these factors vary between alternatives. If the factors are understood, then the type and severity of effec will be better understood.

Table II-4 displays methods and tools available for use in each alternative. Each alternative has a unique set of methods and tools. For example, herbicide methods are not available in alternative F, prescribed fire is not available in alternative G, aerial herbicide application tools are available only in varying rates in alternatives D, G, H, and Modified D, and raking tools are only available in alternatives C and H. Careful review will find many other differences.

Table II-5 shows the number of acres treated with each method in each alternative, and lists total acres treated. Total acres range from zero to 173,169. Table II-6 is just another way of expressing data in table II-5 in order to more clearly show how use of each method varies from alternative to alternative. In all alternatives where vegetation management is done, biological represents a small fraction of treatments. Use of other methods varies substantially between alternatives. For example, in alternative E about 10 percent of the total acres are treated with herbicides, while in alternative G 35 percent of the total acres are treated (table II-6). Tables II-5 and II-6 should be used together, however, because total acres treated by all methods vary. Note that in alternative B, about 23 percent of the acres treated are done with mechanical methods, yet this is only 12,184 acres. Compare this with alternative H where only 13 percent of the acres are treated with mechanical methods, but number of acres treated is 22,561.

Table II-7 lists frequency of recurring treatments in each alternative. As with the other factors, significant variations exist.

Environmental Effects

Numerous known and estimated environmental effects are discussed in chapter IV which forms the scientific and analytic basis for the comparisons in this section (40 CFR Part 1502.16). Chapter IV discloses effects on each environmental element (such as soil, air, or human health). This section compares how all environmental elements are affected in each alternative. Chapter IV is technical and lengthy. This section summarizes information from chapter IV, and is less technical.

A comparison of the principal environmental effects for each alternative is presented in table II-8. Socioeconomic effects are shown in table II-9.

Effects on wildlife are measured as variety of habitats. While direct effects do occur, the indirect effect of alteration of habitat is the most important variable affecting wildlife. Habitat is described by successional stage. Where areas are not treated at all, they tend to progress toward later successional stages.

Table II-4.--Comparison of methods and tools by alternative

A (No Action)	B	C (Current)	D (Draft Preferred)	MODIFIED D (Final Preferred)
None	Herbicides Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Mech. ground tools Boomsprayer Granular spreader Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Aerial tools Helicopter Mech. ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Aerial tools Helicopter Mech. ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayer Spotguns Hypo-hatchets Injectors Axe & sprayer
None	Mechanical Low soil disturbance Mowing Chopping Shearing Ripping Scarifying	Mechanical Low to high disturbance Mowing Chopping Shearing Ripping Scarifying Piling Disking Raking	Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light Disking	Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light Disking
None	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools
None	Fire Low intensity Dormant season burns Aerial tools Ground tools	Fire Low to high intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to mod. intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to mod. intensity Dormant and growing season burns Aerial tools Ground tools
None	Biological Livestock	Biological Livestock	Biological Livestock	Biological Livestock

E	MODIFIED E	F	G	H
Herbicides Mech. ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchet Injectors Axe & sprayer	Herbicides Mech. ground tools Boom Sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides None	Herbicides Aerial tools Helicopter Mech. ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchets Injectors Axe & sprayer	Herbicides Aerial tools Helicopter Mech. ground tools Boom sprayer Granular spreader Hand ground tools Backpack sprayers Spotguns Hypo-hatchets Injectors Axe & sprayer
Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to mod. soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Light disking	Mechanical Low to high soil disturbance Mowing Chopping Shearing Ripping Scarifying Piling Raking Light disking
Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools	Manual Power tools Hand tools
Fire Low to mod. intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to mod. intensity Dormant and growing season burns Aerial tools Ground tools	Fire Low to mod. intensity Dormant and growing season burns Aerial tools Ground tools	Fire None	Fire Low to high intensity Dormant and growing season burns Aerial tools Ground tools
Biological Livestock	Biological Livestock	Biological Livestock	Biological Livestock	Biological Livestock

Table II-5.--Comparison of acres treated by alternative

Method	A	B	C	D	Mod D	E	Mod E	F	G	H
					Alternative					
Herbicide										
Selective	0	4,045	18,492	25,317	24,825	9,766	5,992	0	29,768	25,852
Broadcast	0	1,960	6,002	8,832	4,510	2,827	1,537	0	7,672	25,132
Subtotal	0	6,005	24,494	34,149	29,335	12,593	7,529	0	37,440	50,984
Mechanical	0	12,184	24,859	19,569	23,221	29,191	25,432	29,786	27,906	22,561
Fire	0	22,425	44,807	46,553	46,753	30,902	33,833	47,657	0	60,109
Manual	0	11,034	33,048	26,937	27,899	46,844	38,697	49,765	38,729	35,180
Biological	0	2,128	2,837	2,837	2,837	2,837	2,837	2,837	2,837	2,837
TOTAL	0	53,776	130,045	130,045	130,045	122 367	108,328	130,045	106,912	171,671
% Treated**	0	1.0	2.5	2.5	2.5	2.4	2.1	2.5	2.1	3.3

**Portion of total 5.2 million acres treated on an annual basis.

Table II-6.--Comparison of method mix (% acres treated within alternatives)

Method	A	B	C	D	Mod D	E	Mod E	F	G	H
					Alternative					
Herbicide	0	11.2	18.8	26.3	22.6	10.3	7.0	0	35.0	29.7
Mechanical	0	22.6	19.1	15.0	17.9	23.9	23.5	22.9	26.1	13.1
Fire	0	41.7	34.5	35.8	35.9	25.2	31.2	36.6	0	35.0
Manual	0	20.5	25.4	20.7	21.4	38.3	35.7	38.3	36.2	20.5
Biological	0	4.0	2.2	2.2	2.2	2.3	2.6	2.2	2.7	1.7

Table II-7--Average treatment frequencies (years) by alternative

Treatment of:	A	B	C	D	Mod D	E	Mod E	F	G	H
Hazardous fuels	None	7	6	6	6	9	9	6	None	4
Threatened & Endangered Species Habitat	None	3	3	3	3	3	3	3	3	3
Other Wildlife Habitat	None	4	4	4	4	4	4	4	4	3
Balds	None	4	3	3	3	3	3	3	3	2
Trails	None	3	1	1	1	1	1	1	1	1
Roads-Forest Service	None	4	3	3	3	3	3	3	3	2
Co/State roads	None	2	1	1	1	1	1	1	1	1
Utility Lines	None	7	6	6	6	6	6	6	6	4
Railroads	None	1	1	1	1	1	1	1	1	1
Pipelines	None	3	2	2	2	2	2	2	2	1
Recreation Sites	None	2	1	1	1	1	1	1	1	1

Evaluation of effects on threatened, endangered, proposed and sensitive species of plants and animals broadly considers whether or not it is possible to achieve recovery. Recovery is the primary objective of management activities for these species.

Human health effects are measured as risk to human health from use of herbicides, and risk of accidental injury from use of vegetation management tools. Indirect effects such as accidents related to wildfire occurrence and suppression are also stated.

Effects on vegetation are generally reflected as changes in species composition. Species composition is the kinds, numbers, and distribution of plants growing on a site. Table II-8 shows effects on woody and herbaceous vegetation and ranks alternatives based on their effects on woody vegetation. Generally, treatments (or lack of treatment) favoring woody vegetation will negatively affect herbaceous vegetation, and conversely.

Alternatives are ranked according to their potential to cause long-term soil productivity losses. Risk of lost soil productivity is based on soil compaction and loss of organic matter, nitrogen, and soil organisms. Such effects may occur from use of prescribed fire, raking, or piling. Effects vary depending on soil type. Alternatives are ranked by determining how much of each treatment is used, and on which soil types.

Two different effects on water and aquatic life are displayed in table II-8. Tons of sediment produced annually means the estimated sediment produced by vegetation management treatments which reaches streams despite mitigation measures. The other effect is the potential for herbicide pollution of streams.

Table II-8.--Comparison of environmental effects, by alternative

		Human Health	Wildlife	T&E Species	Vegetation
	Comparison Measure(s)	Risks to human health, risks of injury.	Variety of habitats.	Plant and animal species recovery.	Effect on woody under- and midstory species (ranking).
ALTERNATIVE	A (No Action)	No direct risks, but some from wildfire. Lowest overall risk.	Highly favors mid-late successional species. Early successional in natural disturbances and harvest areas only.	Habitat not managed, many species decline. Recovery of many populations not likely.	Woody under- and midstory highly favored. Intolerant hardwood and pine decline. Ranking = 1 (least effect)
	B	Herbicide risks are low; less than C. Risk of injury low for all other methods.	Favors mid-late successional species, but less than A. More early successional habitat than A.	Recovery of known populations likely.	Woody under- and midstory favored due to selective herbicides, light mechanical and fire, more manual. Ranking = 2.
	C (Current)	Current level. Herbicide and mechanical risks low; manual moderate to high. Fire-related risk is high.	Mixed early-mid-late successional habitats. Intensive treatments favor early successional species.	Recovery of known populations likely.	Woody under- and midstory reduced due to broadcast herbicides, low-high mechanical and fire. Ranking = 9.
	D (Draft Preferred)	High risk from fire, moderate from manual and herbicide. Slight public risk from aerial herbicide drift.	Mixed early-mid-late successional habitats. More herbicides and fire favor early-mid species.	Recovery of known populations likely.	Woody under- and midstory reduced, but less than C, due to more herbicides and mechanical, moderate fire. Ranking = 7.
	MODIFIED D Final Preferred	High risk from fire, moderate from manual and herbicide. Minimal public risk from aerial herbicide drift.	Mixed early-mid-late successional habitats. More herbicides and fire favor early-mid species, but less than D.	Recovery of known populations likely.	Woody under- and midstory reduced, but slightly less than D due to less herbicides, more selective. Ranking = 6.
	E	High accident risk from manual and fire; moderate from mechanical; low from herbicides.	Mixed early-mid-late successional habitats, but early stage limited due to more manual.	Recovery of known populations likely.	Woody under- and midstory favored due to less fire and herbicides, more manual. Ranking = 4.
	MODIFIED E	High accident risk from manual and fire; moderate from mechanical; low from herbicides.	Mixed early-mid-late successional habitats, but early stage limited due to more manual.	Recovery of known populations likely.	Woody under- and midstory favored due to less fire and herbicides, more manual, but less than E. Ranking = 5.
	F	No risk from herbicide; highest accident risk from manual and fire. Moderate from mechanical.	Favors mid-late successional species due to high use of manual; more than E, but less than B.	Recovery of known populations likely.	Woody under- and midstory increased due to more manual, low-moderate fire. Ranking = 3.
	G	No risk from fire, high from manual, moderate from herbicide and mechanical. Low public risk from aerial herbicide drift.	Mixed early-mid-late successional habitats. More herbicides and mechanical slightly favor early-mid species.	Recovery of most known populations likely, but some fire-dependent species may not recover.	Woody under- and midstory reduced, more than D, due to more herbicides and mechanical. Ranking = 8.
	H	Highest herbicide health risk and second highest overall accident risk.	Highly favors early successional species.	Recovery of known populations likely.	Woody under- and midstory reduced most. Intensive treatments highly favor herbaceous understory. Ranking = 10 (most effect).

Soil	Water & Aquatics	Air	Visual Quality	Cultural Res.
Risk of long-term soil productivity loss.	Tons sediment, risk of herbicide pollution.	Acres burned. Tons of smoke produced annually.	Visibility of work. Meets VQO's.	Risk of loss or damage.
Low risk due to some intense wildfires.	Wildfires produce some sediment. No risk of herbicide pollution.	Slash burns = 0, underburns = 0, wildfires = 10,400 ac., producing 6,100 tons of smoke.	No work done. VQO's not met for vistas, developed recreation sites, or other areas requiring manipulation.	Lowest - though wildfire may damage architectural resources.
Negligible risk, 3 percent of A, due to restricted use of low disturbance tools.	Treatments produce 110 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 1,400 ac., underburns = 20,500 ac., wildfires = 8,000 ac., producing 7,900 tons of smoke.	Work less visible than present. VQO's will generally be met.	Low - wildfire may damage architectural resources.
Moderate risk, 24 times that of A, due to some use of high disturbance tools.	Treatments produce 1,510 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 5,600 ac., underburns = 38,300 ac., wildfires = 8,000 ac., producing 11,800 tons of smoke.	High visibility, significant disruptions. VQO's will generally be met.	High.
Very low risk, 24 percent of A, due to use of low to moderate disturbance tools.	Treatments produce 590 tons of sediment. Some risk of herbicide pollution.	Slash burns = 7,000 ac., underburns = 38,500 ac., wildfires = 8,000 ac., producing 12,400 tons of smoke.	Similar to C. VQO's will generally be met.	Moderate.
Very low risk, 24 percent of A, due to use of low to moderate disturbance tools.	Treatments produce 510 tons of sediment. Little risk of herbicide pollution.	Slash burns = 7,000 ac., underburns = 38,700 ac., wildfires = 8,000 ac., producing 12,400 tons of smoke.	Similar to C. VQO's will generally be met.	Moderate.
Very low risk, 12 percent of A, due to use of low to moderate disturbance tools.	Treatments produce 390 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 600 ac., underburns = 29,300 ac., wildfires = 8,000 ac., producing 9,400 tons of smoke.	Lower overall visibility. VQO's will generally be met.	High.
Very low risk, 16 percent of A, due to use of low to moderate disturbance tools.	Treatments produce 240 tons of sediment. Negligible risk of herbicide pollution.	Slash burns = 3,600 ac., underburns = 29,200 ac., wildfires = 8,000 ac., producing 9,900 tons of smoke.	Lower overall visibility. VQO's will generally be met.	High.
Very low risk, 33 percent of A, due to use of low to moderate disturbance tools.	Treatments produce 750 tons of sediment. No risk of herbicide pollution.	Slash burns = 8,400 ac., underburns = 38,300 ac., wildfires = 8,000 ac., producing 12,900 tons of smoke.	Higher visibility than C. VQO's will generally be met.	High.
Low risk, equal to A, due to some intense wildfires and low to moderate disturbance tools.	Treatments produce 460 tons of sediment, wildfires some. Some risk of herbicide pollution.	Slash burns = 0 ac., underburns = 0 ac., wildfires = 10,400 ac., producing 6,100 tons of smoke.	Treatment areas less visible than at present. VQO's will generally be met.	Moderate.
Highest risk, 36 times that of A, due to emphasis on high disturbance tools.	Treatments produce 2,150 tons of sediment. Most risk of herbicide pollution.	Slash burns = 5,000 ac., underburns = 54,000 ac., wildfires = 8,000 ac., producing 12,700 tons of smoke.	Foreground and middleground strongly influenced by work. May not meet VQO's.	High.

Effects on air quality from vegetation management activities result mainly from smoke produced by prescribed fires. Some is also produced by wildfires, and in some alternatives, lack of vegetation management increases the acres burned by wildfire. Table II-8 displays the numbers of acres burned by all types of fires and lists the total tons of smoke produced annually.

Visibility of work and achievement of visual quality objectives are two measures of effects on visual quality. Whether or not vegetation management work can be seen by the average user depends largely upon how many acres are treated and where the work is located. An additional factor contributing to visibility is intensity of work. Vegetation management treatments often improve appearances of harvested sites. Visual quality objectives (VQO's) are goals for desired visual conditions which have been established for all landscapes.

An estimate of risk of damage or loss is used to state effects on cultural resources. Damage or loss is most likely to occur wherever the ground is disturbed. Some cultural resources may also be affected by fire. Generally, effects from ground disturbance increase with depth of penetration by the tool being used, and with soil displacement. Risks related to fire increase with increased wildfire occurrence, but generally not with increased use of prescribed fire.

Economic and Social Effects

Economic and social effects are in table II-9. Six types of effects are shown.

Table II-9.--Effects of alternatives on socioeconomics

Alternative	Total Cost	Cost/Acre	Indirect Cost	Resource Outputs	User Expectations	Employment Opportunity
A No Action	N/A	N/A	Highest	Favors unmanaged	Favors primitive	Lowest
B	$ 1,646,091	$31.87	Much higher than current	Favors unmanaged	Favors primitive	Much lower than current
C Current	6,965,310	54.76	Moderate	Allows both managed and unmanaged	Favors semi-primitive to rural	Moderate
D Draft Preferred	6,874,578	54.04	Lower than current	Comparable to current	Favors semi-primitive but allows all settings	Slightly lower than current
MODIFIED D Final Preferred	6,934,791	54.52	Moderate	Comparable to current	Favors semi-primitive but allows all settings	Comparable to current
E	7,294,069	61.02	Higher than current	Slightly lower than current	Comparable to D	Slightly higher than current
MODIFIED E	7,208,850	68.34	Much higher than current	Favors unmanaged	Favors semi-primitive	High
F	6,722,110	52.84	High where herbicides are not used	Comparable to current	Favors semi-primitive to rural	High
G	5,620,502	54.00	High where fire is not used	Comparable to current	Favors semi-primitive to rural	Lower than current
H	9,103,502	53.92	Lower than current	Favors managed	Favors roaded natural/rural	High

Total cost reflects the annual expenditure necessary to accomplish the vegetation management program. It is calculated by determining the cost of using each method for each activity proposed, and multiplying by the number of acres treated.

Cost per acre is actually an average cost determined by dividing total cost by total acres treated. Average costs are influenced by methods used for treatment, as some methods are more costly than others.

Indirect costs and opportunity costs are extremely difficult to quantify. It is also not always easy to determine who pays these costs. For example, if good silvicultural practices aren't used, sites won't produce wood products to their capability. This results in lower harvest volumes, thus lower receipts to the treasury. But, lower receipts result in lower payments to counties, which in turn often results in higher taxes to maintain services. Another example is that low or no maintenance of rights-of-way causes damage to facilities within them. For an electric transmission line, the utility company spends more for repairs, but these additional costs are passed on to consumers and shareholders. Also, in some situations, manual methods may be ineffective due to sprouting and require multiple treatments and substantially increased costs.

Resource outputs are classed as managed or unmanaged. While most outputs such as wildlife, timber, recreation, and forage require some form of management, there are some like wilderness or late successional species which occur in the absence of vegetation manipulation.

User expectations cover a range from primitive to rural settings. These settings are explained in chapter III. Generally, as more vegetation treatments are done, more expectations toward the rural end of the scale can be met.

Employment opportunity is stated qualitatively (low to high), and reflects only those jobs directly associated with vegetation management. Numbers of jobs available depend on the labor intensity of methods used, total dollars spent, and numbers of acres treated. Manual methods are the most labor intensive, but selective herbicide treatments also have a high labor component.

H. SUMMARY OF COMPARISON OF ALTERNATIVES

This section is a brief summary of the effects of the alternatives displayed in tables II-8 and II-9. For more detail, see section IV.N.

Alternative A has least risk of effects because no treatment is done. No herbicides are used so there is no risk of adverse **human health** effects or **water pollution** from them. Increased fuel loads raise the risk of more **wildfires** with greater intensity, increasing risk to persons and properties on adjacent lands. Mid- to late-successional **wildlife** species benefit from lack of treatment, while early successional species lose habitat. **Threatened, endangered, proposed, and sensitive species** have mixed effects: some species gain and others lose habitat with recovery unlikely. Woody **vegetation** thrives while herbaceous and shade-intolerant plants decline. **Soil productivity** may be impaired by severe wildfires. **Air quality** is affected least in this alternative because of the lack of prescribed fire. **Visual quality** is reduced because vegetation is allowed to encroach upon scenic views and vistas. Risk to **cultural resources** is low although damage could occur from wildfires. Because no funds are spent for vegetation management, **costs** are low in this alternative. **Output** of managed resources declines substantially. There is no **employment** provided by vegetation management.

Alternative B is restricted to treatments that achieve minimum resource objectives. Risk to **human health and safety** is minimized by limited herbicide use and a restricted program. Effects on **wildlife** are similar to those in alternative A, but fire-dependent species benefit more because over 10,000 acres are prescribed burned for wildlife and **T&E species**. Recovery of threatened, endangered, proposed, and sensitive species is likely if impacts from external factors are controlled. Selective application of herbicides and prescribed fire results in small losses of nontarget plants. **Herbaceous species** decrease in number, and a greater amount of **woody species** grow into the midstory and understory. Impairment of **soil productivity** is minimal. Because all treatment intensities are low, effects on **water and aquatics** from herbicides and sediments are negligible. Annual **smoke emissions** from wildfires and prescribed fires are estimated to be about 30 percent higher than in alternative A. Work is much less **visible** than currently. Risk to **cultural resources** is lowest except for alternative A. Alternative B primarily benefits those who enjoy primitive forest settings. **Employment opportunities** are lowest of all the alternatives involving management activities. **Managed outputs** decline from present levels. Per acre and total **costs** are lowest of all alternatives using vegetation management.

Alternative C continues present levels of treatment specified in Forest Land and Resource Management Plans. **Human health** risk from herbicides is low for workers and the public. Risk of **injury** from manual methods is low to moderate while risk from fire-related **accidents** is high. A wide range of vegetation management tools provides a variety of habitats and successional stages for many **wildlife** species. Mitigation measures assure adequate recovery of **threatened, endangered, proposed, and sensitive species**, and recovery is likely if impacts from external factors are controlled. Broadcast treatment of herbicides, use of low to high intensity burns, and low to high disturbance mechanical tools increase **herbaceous species** and reduce **woody species**. Such treatments also increase risk of damage to nontarget plants. Over time, risk of **soil impairment** is moderate due to some use of high intensity treatments, and overall risk to **water and aquatics** is low due to 1,510 tons of **sediment** produced per year. Effects on herbicide concentrations in water are minimal. Annual **smoke emissions** from prescribed fires and wildfires are estimated to be about 95 percent higher than in alternative A. **Visual impacts** result mainly from prescribed fire, herbicide, and mechanical treatments, but degree of impairment is generally short-term. Use of high-disturbance mechanical tools represents high potential for **cultural resource** damage. **Socioeconomic conditions** offer a balance for those who enjoy primitive or semi-primitive settings and for those who enjoy more developed forest settings. There is a high level of **employment opportunity**. Per acre **costs** are exceeded only by those in alternatives E and I; total costs are higher than alternatives A, B, D, Modified D, F, and G.

Alternative D has more extensive use of prescribed fire and herbicides; such use poses low (but higher than C) **health risk** to workers and the general public. Decreased use of manual methods decreases risk to **worker safety**. Preference for selective herbicide treatments and use of low to moderate intensity tools produce a varied mix of **wildlife** habitats and **plant** communities. Management effects on **threatened, endangered, proposed, and sensitive species** are similar to those in alternative C. Risk of **soil impairment** is expected to be very low due to use of low to moderate intensity tools. Risk to **water and aquatic life** from 590 tons of sediment and limited aerial herbicide treatment is very low. Annual **smoke emissions** from prescribed fires and wildfires are estimated to be about double those in alternative A. **Visual impacts** are roughly the same as those in alternative C. With alternative D, there is reduced risk of damage to **cultural resources** because mechanical treatments are reduced from Plan levels. **Socioeconomic conditions** include possible conflicts over aerial application of herbicides. Otherwise, this alternative provides primitive and rural forest settings. **Employment opportunities** are slightly lower than present levels. Per acre **costs** are less than in alternatives C, Modified D, E, H, and I; total costs are higher than alternatives A, B, F, and G.

Alternative Modified D has more extensive use of prescribed fire and herbicides, posing low (but higher than C) **health risk** to workers and the public. Decreased use of manual methods decreases risk to **worker safety**. Preference for selective herbicide treatments and use of low to moderate intensity tools produce a varied mix of **wildlife habitats** and **plant** communities with slightly more control of results than alternative D. Effects on **threatened, endangered, proposed, and sensitive** species are similar to those in alternative C. Risk of damage to **soil productivity** is very low due to use of low to moderate intensity tools. Risk to **water and aquatic life** from 510 tons of sediment and limited aerial herbicide treatment is very low. Annual **smoke emissions are** about double those in alternative A. **Visual impacts are** about the same as in alternative C, but sometimes less obvious. There is reduced risk to **cultural resources** due to fewer mechanical treatments. **Socioeconomic conditions** include possible conflicts over aerial application of herbicides (though less intense than in alternative D). Settings ranging from primitive to rural are provided. **Employment opportunities** are only slightly lower than present. Per acre **costs** are lower than alternative C, but higher than alternative D. Total costs are higher than alternatives A, B, D, F, and G.

Alternative E reduces use of prescribed fire and herbicides. Reduced use of herbicides with no aerial application results in low to very low risk of adverse **human health** effects. Increased use of manual tools significantly increases risk to worker safety. **Wildlife habitat** is reduced for some species such as turkey because of the long burning cycle, while other species such as amphibians and reptiles benefit from downed logs created by mechanical treatments. **Threatened, endangered, proposed, and sensitive species** are likely to recover if impacts from external factors are controlled. **Woody species** are slightly favored over **herbaceous species**, especially where manual methods are used instead of mechanical. Risks to **soil productivity** are lower than all other alternatives except B. Low to moderate treatment intensity results in the third-lowest sediment and herbicide risk to **water and aquatics**. Effects on **air quality** from prescribed fires and wildfires are lower than those in all other alternatives except A, B, and G. There is little difference in **visual quality** between this alternative and alternatives C and D. Impact on **cultural resources** is high. **Outputs** are slightly below Forest Plan levels. Alternative E favors primitive or semi-primitive **settings** but allows for rural settings as well. **Employment opportunities** are high. Per acre **costs** are second-highest and total costs are exceeded only by alternative H.

Alternative MODIFIED E substantially reduces the use of prescribed fire and herbicides. Reduced use of herbicides and no aerial application results in very low risk of adverse **human health** effects. Increased use of manual tools increases risk to **worker safety**, but reduced use of fire reduces some risk associated with its use. Risks to non-target **vegetation** are very low due to limited broadcast herbicide treatments and emphasis on manual methods.

Wildlife such as turkey are adversely affected by longer burning cycles. **Threatened, endangered, proposed, and sensitive** species are likely to recover, but management is more difficult due to availability of only fire and manual methods for habitat treatments. Risks of lost **soil productivity** are very low. Risks to **water and aquatic life** are extremely low. **Smoke emissions** are about 62 percent higher than in alternative A. **Visual impacts** are comparable to current. Decreased use of prescribed fire causes only slightly greater risk to **cultural resources**, but there is also a slightly greater risk from additional mechanical treatments. **Outputs** are below Forest Plan levels. Primitive and semi-settings are favored though all settings are provided. **Employment opportunities** are high. Per acre **costs** are highest and total costs are third highest, after alternatives E and H.

Alternative F does not use herbicides, so risk from herbicides to **human health** or **water** is nil. Risks to **worker safety** are greatest in this alternative because of the increased use of prescribed fire and manual methods. **Wildlife habitat** is mixed for early, mid-, and late-successional species. **Threatened, endangered, proposed, and sensitive species** are likely to recover if impacts from external factors are controlled. Growing-season burns for site preparation and on balds increase number and variety of **herbaceous species**. Emphasis on manual and light mechanical tools favor **woody species**. Effects on **soil productivity** are very low. Sediment effects on **water and aquatics** are minimal. Effects on **air quality** from prescribed fires and wildfires are higher than any other alternative. **Visual impacts** occur from fire, manual, and mechanical treatments, but they meet visual quality objectives. Risk to **cultural resources** are slightly higher than at present because of the increased use of prescribed fire. Alternative F balances primitive and semi-primitive and rural **settings**. **Employment opportunities** are very high because of the large number of manual treatments. **Outputs** are at plan levels. Per acre **costs** are lowest except for alternative B. Total costs are higher than alternatives A, B, and G.

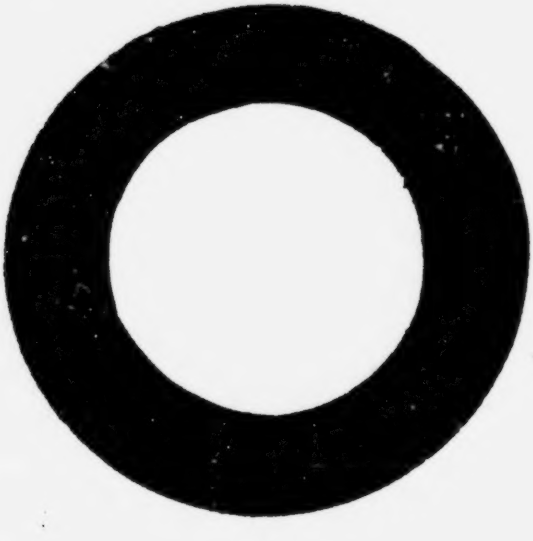
Alternative G does not use prescribed fire. This increases **health risks** to the public and to forest workers from wildfires. This alternative also has high risk to **worker safety** because of increased use of manual methods. Mechanical and herbicide methods cause low (but higher than C) risks to **human health and safety**. Habitat for many **wildlife** species decline due to lack of prescribed fire, which may also prevent recovery of some fire-dependent **threatened, endangered, proposed, and sensitive species**. Other treatments allow for maintenance or recovery of some species. Shade-tolerant **woody species** tend to increase with

herbaceous species declining. **Soil productivity** may be impaired by severe wildfires which increase in this alternative. Risk to **water and aquatic life** from 460 tons of sediment and limited aerial herbicide treatment is very low. **Air quality** is affected least in this alternative due to the lack of prescribed fire. **Visual effects** are usually insignificant after 3 to 4 months. Treatments meet visual quality objectives. Although the lack of prescribed fire could magnify some risks to **cultural resources**, overall risks are comparable to the present. Increased use of herbicides might lead to social conflict. Increased manual treatments boost **employment**, but elimination of prescribed fire reduces opportunities. Overall, employment might drop for forest-related jobs. **Output** levels remain unchanged from the present. Per acre **costs** are slightly lower than current. Total costs are lowest except for alternatives A and B.

Alternative H achieves maximum vegetation control. **Human health risks** are greatest in this alternative due to the most use of herbicides without extra mitigations. Non-target **vegetation** is at highest risk due to expansion of intensive broadcast treatments. Herbaceous species predominate and woody species are reduced. This alternative limits production of hard- and soft-mast used by deer, turkey, and other **wildlife** species. Other species might also be adversely affected. Recovery is likely for **threatened, endangered, proposed, and sensitive species** if impacts from external factors are controlled. Impacts on **soil productivity** and on **water and aquatic life** are highest in this alternative due to emphasis on intensive treatments. **Smoke emissions** from prescribed fire and wildfires are the second highest of all the alternatives. This alternative creates significant visual impacts, and individual treatments might not meet **visual quality** objectives. Extensive use of prescribed fire and the full range of mechanical treatments poses a high risk to **cultural resources**. Alternative H directly benefits those who enjoy a rural forest **setting** and negatively affects those who like primitive settings. Social conflict arises from the magnitude of change from current treatments. **Employment opportunities** are higher than other alternatives because more acres are treated. **Outputs** exceed Forest Plan levels. Total **costs** are highest (highest total acres), but per acre costs are lower than alternatives C, D, Modified D, E, G, and I.

I. IDENTIFICATION OF PREFERRED ALTERNATIVE

Alternative Modified D is the Forest Service's preferred alternative.



Affected Environment

Chapter III

AFFECTED ENVIRONMENT

IN BRIEF

Part A describes the geographic area analyzed and gives a general description of physiography and climate. Part B gives more detailed descriptions of facets of the environment that may be affected by proposed activities.

A. PHYSICAL AND BIOLOGICAL SETTING

This environmental impact statement relates to national forests in the Appalachian Mountains (table III-1). These lands total 5.2 million acres in eight states.

Table III-1.--Administrative units covered by the EIS

STATE	NATIONAL FOREST
Alabama	Bankhead, Talladega (Talladega Div.)
Georgia	Chattahoochee
Kentucky	Daniel Boone, Jefferson
North Carolina	Nantahala, Pisgah
South Carolina	Sumter (Andrew Pickens Ranger District)
Tennessee	Cherokee
Virginia	George Washington, Jefferson
West Virgina	George Washington, Jefferson

All or parts of 10 national forests are covered. These units are managed by eight Forest Supervisors.

1. Physiography

The South contains 5 physiographic divisions (figure III-1). This EIS covers the Appalachian Highlands, or Appalachian Mountains. This area contains 3 physiographic provinces arranged in long, northeast-to-southwest belts.

(1) The BLUE RIDGE province on the east is a rugged highland on old metamorphic (pressure-hardened) and igneous (volcanic) rocks that rises sharply above the Piedmont and Ridge and Valley provinces. Steep, rounded mountains are

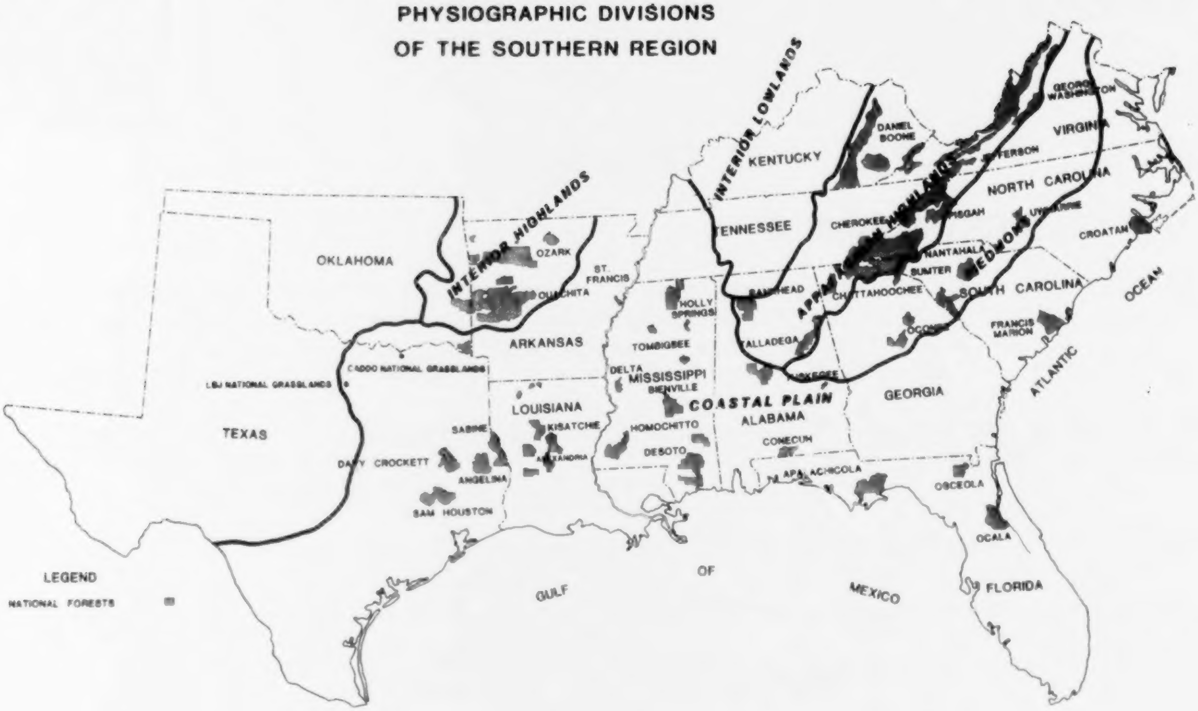

PHYSIOGRAPHIC DIVISIONS
OF THE SOUTHERN REGION
INTERIOR LOWLANDS
INTERIOR HIGHLANDS
APPALACHIAN HIGHLANDS
PIEDMONT
COASTAL PLAIN
KENTUCKY
TENNESSEE
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
LOUISIANA
ARKANSAS
OKLAHOMA
TEXAS
FLORIDA
GEORGE WASHINGTON
JEFFERSON
DANIEL BOONE
CHEROKEE
PISGAH
UWHARRIE
CROATAN
NANTAHALA
SUMTER
CHATTAHOOCHEE
OCONEE
FRANCIS MARION
BANKHEAD
TALLADEGA
TUSKEGEE
CONECUH
APALACHICOLA
OSCEOLA
OCALA
OZARK
OUACHITA
ST. FRANCIS
HOLLY SPRINGS
TOMBIGBEE
DELTA
BIENVILLE
HOMOCHITTO
DESOTO
KISATCHIE
SABINE
DAVY CROCKETT
ANGELINA
SAM HOUSTON
CADDO NATIONAL GRASSLANDS
LBJ NATIONAL GRASSLANDS
ATLANTIC
OCEAN
GULF
OF
MEXICO
LEGEND
NATIONAL FORESTS

Figure III-1.--Physiographic subregions and States in the Forest Service's Southern Region.

deeply carved by many branching streams. In Virginia, this province forms a complex **Narrow Ridge** broken into several segments by water and wind gaps, with altitudes of 600 to 4,000 feet. To the South, it consists of numerous massive mountain ranges drained mostly by rivers flowing northwest, with altitudes of 1,500 to more than 6,000 feet. The **Blue Ridge Mountains** in the east are an array of rounded mountain masses separated by broad lowlands. The **Unaka Mountains** in the west are a series of rugged, linear ridges atop narrow valleys and coves, deeply cut by through-flowing rivers.

(2) The RIDGE AND VALLEY province in the center is a series of parallel ridges and valleys formed by intense deformation of old sedimentary (water-deposited) rocks. Limestone and shale valleys are topped by narrow, linear, even-crested sandstone ridges. Straight streams draining steep sideslopes empty into long rivers that run down the valleys and breach the ridges at short right angles. Water and wind gaps break the ridges into hundreds of segments. The Great Valley is a continuous lowland along the eastern edge. In the **Folded Highlands** of Virginia, high ridges prevail over narrow valleys, major rivers cut directly across the

province, wind gaps are abundant, sinkholes and sinking creeks are common, and altitudes are 600 to more than 4,500 feet. In the **Faulted Lowlands** to the South, broad valleys prevail over low ridges, major rivers run lengthwise down the valleys, and altitudes are 600 to 2,000 feet.

(3) The APPALACHIAN PLATEAUS province on the west is a rolling to rugged upland on young limestones, sandstones, shales, and coal. Smooth, rounded hills and mountains are carved by branching streams. The rugged **Cumberland Mountains** astride the Kentucky, Virginia, and Tennessee borders are deeply carved with narrow ridges and valleys and steep slopes and have altitudes of 1,200 to more than 4,000 feet. The **Cumberland Plateau** contains three portions. In the **Kentucky Basin**, it grades eastward from a sandstone-capped plateau cut by deep gorges, to low shale hills, to rugged highlands of narrow ridges and valleys and steep slopes, with altitudes of 1,100 to 2,000 feet. In the **Tennessee Plateau**, it is a true sandstone plateau, with young valleys that deepen toward the outer edges and altitudes of 1,500 to 3,000 feet. In the **Table Plateaus** of Alabama, it is broken into mesa-like terrain with altitudes of 600 to 2,000 feet.

Mountain terrain contains five basic landforms. Ridges are convex and may be droughty if narrow or rocky. Upper sideslopes are often straight, while lower sideslopes may be concave with deeper soils enriched in moisture from downslope drainage. Colluvial slopes are gravity-deposited coves and benches with deep soils enriched in moisture and nutrients. Alluvial sites are stream-deposited floodplains and terraces with deep soils, also enriched in moisture and nutrients. In addition to these landforms, very steep terrain may also contain rocklands, which include rock outcrops and talus slopes with little or no soil that are usually droughty.

2. Climate

Most of the Appalachians has a humid continental climate with hot, humid summers and cool winters. The Ridge and Valley and Cumberland Plateau in Georgia and Alabama have a subtropical climate with mild winters. Gulf, Atlantic, and continental air masses all affect the weather, with Gulf air prevalent in the south, Atlantic air in the east, and continental air in the northwest. Thunderstorms are frequent in spring and summer. Winter precipitation is caused by frontal systems.

Precipitation increases with altitude and proximity to maritime air masses. Annual precipitation ranges from 30-40 inches in the valleys of northern Virginia, to 45-55 inches at the base of the mountains, to 80-100 inches atop high ranges in the Blue Ridge and Unaka mountains. Precipitation falls 120-160 days per year, increasing with altitude and to the north. In most years, even the driest summer month receives more than 2 inches of rain. But spring and summer droughts do occur, and fall is commonly the driest season. Precipitation is generally acidic.

Thunderstorm activity is greatest in the Cumberland Plateau in Alabama, the Ridge and Valley province in Georgia, and the southern Blue Ridge province. Rainfall intensities generally increase with altitude and to the south, being lowest in the Cumberland Plateau of Kentucky and highest atop high ranges in the Blue Ridge and Unaka mountains. Valley fog is common, especially in the Unaka and Cumberland mountains and the northern Ridge and Valley province. Annual snowfall ranges from 5 inches in the south to more than 30 inches atop high ranges in the Blue Ridge and Unaka mountains.

Temperatures decrease with increasing altitude and latitude. Average annual temperature is 45-55°F. July temperatures range from highs of 75-90°F to lows of 55-65°F. January temperatures range from highs of 40-55°F to lows of 20-35°F. The growing season ranges from less than 150 days in the north and the high mountains to 200 days in the south. Temperatures exceed 90°F only 5-10 days per year in the high mountains and 60 days per year in the south. Freezing temperatures occur 60 days per year in the south to more than 120 days per year in the high mountains and the north. Relative humidity averages 70-75 percent, being highest in summer and lowest in early spring and fall. The area receives only 45-55 percent of possible sunshine.

Topography exerts a strong effect on the local climate. As altitude increases, precipitation rises, temperature drops, and growing season shortens. North to east slopes are more cool and moist than flat terrain, and south to west slopes are more warm and dry. Downslope winds at night commonly bring cooler air to valley bottoms and form temperature inversions that promote valley fogs.

B. ENVIRONMENTAL ELEMENTS

1. Vegetation

a. Forest

Vegetation within the Appalachian Mountain forest area is comprised of highly complex mixtures of species that vary by elevation; slope position, aspect, and steepness; landform; and soil type. These factors define a site's temperature, moisture, and nutrient regimes. Temperature regime depends on amount of solar energy received. Moisture regime depends on amount of water received and stored versus amount of solar energy received. Nutrient regime depends on the type of rock a soil develops from and on its erosion and deposition history.

As latitude and altitude increase, temperatures drop and growing season shortens. Species favoring cooler, shorter growing seasons replace those needing warmer, longer seasons. For example, most natural stands of loblolly pine in the Appalachians occur at altitudes below 2,000 feet or latitudes below 35 degrees (the southern borders of Tennessee and North Carolina), while most natural stands of white pine are found at higher altitudes or latitudes. Red spruce, on the other hand, occurs only at elevations greater than 3,500 feet, while in the northeastern United States, it occurs at sea level. Another example is Fraser fir which is found only at elevations greater than 4,500 feet in the southern Appalachians.

Slope aspect and steepness change the amount of solar energy a site receives. North to east slopes receive less direct solar energy than flat terrain and so are cooler and wetter (mesic). South to west slopes receive more direct energy and so are warmer and drier (xeric). In general, slopes can be grouped into five classes grading from wettest to driest as follows: northeast/north, east/northwest, southeast, south/west, and southwest. These differences are more pronounced for steeper slopes. Topographic shading can greatly increase site moisture in deep valleys and gorges.

Landform affects a site's moisture and nutrient status. Convex ridges drain promptly and may be droughty if narrow or rocky, and they often have thin topsoil and low fertility. Rocklands (rock outcrops and talus slopes) drain quickly, have little or no soil, and are droughty and sterile. Moisture and fertility increase downslope due to downhill movement of soil water and enhanced soil formation. Colluvial coves and benches and alluvial floodplains and terraces are enriched in moisture and nutrients deposited from upslope and upstream.

Soil depth is directly related to moisture storage capacity, usually increasing from ridges and rocklands to lower slopes to colluvial and alluvial sites. Moisture storage increases from sandy to clayey to loamy soils. The more rock fragments a soil has, the less moisture it can store.

Geology determines soil minerals. Soils derived from granite, sandstone, gneiss, and quartzite tend to be more acid and less fertile than those weathered from shale, slate, and schist. Soils on limestone are more basic and fertile, while those developing in coal mine spoil are rocky, acid, and infertile.

These factors combine to affect a site's growth environment. For example, most of a northeast slope may be cool and moist, while such sites on equivalent southwest slope may be limited to lower slopes or coves where enhanced slope drainage and soil formation can compensate for the greater solar energy striking the slope.

Some plants demand more moisture and nutrients than others for optimum growth. More demanding plants tend to be better suited to middle and higher altitudes; north and east slopes; lower slopes and colluvial and alluvial sites; and deep, neutral, loamy to clayey soils with little rock. Species that compete best under these cooler, wetter conditions include yellow-poplar, northern red oak, sugar maple, yellow buckeye, black cherry, white ash, cucumber tree, white basswood, hemlock, and yellow birch. Less demanding plants tend to be better suited to lower altitudes; south and west slopes; ridges, upper slopes, and rocklands; and shallow, acid, sandy, or rocky soils. Effective competitors under these warmer, drier conditions include chestnut oak, scarlet oak, white oak, red maple, blackjack oak, post oak, shortleaf pine, pitch pine, white pine, and Virginia pine.

Over the years, several classification systems have been developed to group regional vegetation associations. These systems have focused on climatic, geographic, historic, and potential (biological) vegetation occurrence. Of the many systems developed, three commonly used are Braun's (1950) description of forest regions, Kuchler's (1966) potential natural vegetation, and Bailey's (1980) ecoregions. This description uses Kuchler's (1966) potential natural vegetation to give a general description of the Appalachian region.

No one system necessarily details the overstory, midstory, and understory of forests, so examples of some common woody and herbaceous species appear in tables III-2 through III-7. More detailed descriptions of specific forest cover types, vegetation associations, and plant communities can be found in Forest Land and Resource Management Plans, FSH 2409.26, and publications by Arends and McCormick (1987), Cooper and Hardin (1971), Govus (1982), McLeod (1988), and Whittaker (1956). Three broad forest vegetation regions occur in the Appalachian Mountains:

(1) Mixed mesophytic forests cover approximately 7 million acres (Federal, State, and private ownerships within counties that contain National Forest System lands). These forests occur in the Cumberland Plateau and Cumberland Mountain sections of the Appalachian Plateau physiographic province. Both Braun (1950) and Bailey (1980) classified these forests as mixed mesophytic. Braun (1950) described them as the oldest, most complex eastern climax hardwood forests. These forests contain many overstory species that share dominance. Overstory species include sugar maple, American beech, yellow buckeye, yellow poplar, white oak, northern red oak, white basswood, and eastern hemlock. Many species tend to segregate by altitude, aspect, and exposure. In these forests yellow birch, basswood, buckeye,

red maple, northern red oak, yellow poplar, hemlock, and sugar maple are more commonly found at higher elevations or more northerly exposures; while chestnut oak, scarlet oak, black oak, shortleaf pine, pitch pine, and Virginia pine are more commonly found at lower elevations or on shallow soils and dry ridges.

Typically these forests have well-developed woody midstories and understories and also a well-developed herbaceous understory. Shrubs and vines common to these forests include wild hydrangea, American strawberry-bush, white rhododendron, alternate-leaf dogwood, witch-hazel, common spice-bush, mapleleaved viburnum, American bittersweet, Virginia creeper, and cross vine.

Some common herbaceous species include the common maidenhair fern, Christmas fern, bracken fern, ground cedar, May-apple, bloodroot, galax, Dutchman's breeches, dwarf larkspur, dwarf iris, and the blue cohosh. More comprehensive lists of woody and herbaceous species of mixed mesophytic forests are found in tables III-2 and III-3.

(2) Appalachian oak forests cover approximately 11 million acres (Federal, State, and private ownerships within counties that contain National Forest System lands). Also included in this section are the forests Kuchler classified as northern hardwoods and southern spruce-fir forests. These forests occupy the Narrow Ridge section and the Blue Ridge and Unaka Mountains of the Blue Ridge physiographic province, plus all of the Highlands and most of the Lowlands sections of the Ridge and Valley physiographic province. Braun (1950) classified these forests within the oak-chestnut forest regions, while Bailey (1980) identified these as Appalachian oak forests.

Prior to the chestnut blight, these forests were often dominated by the American chestnut. Today drier slopes and ridge sites are dominated by a variety of oak and pine species, while more moist sites are dominated by "cove" forests comprised of the mixed mesophytic species described previously or of northern hardwood species at higher elevations. A small amount of spruce-fir forests occupy the highest elevations.

Most common overstory species in Appalachian oak forests on drier sites and/or lower elevations include white oak, southern red oak, scarlet oak, chestnut oak, red maple, bitternut hickory, pignut hickory, post oak, blackjack oak, shortleaf pine, white pine, and Virginia pine. On more moist sites, basswood, buckeye, and hemlock, and, at higher elevations, yellow birch, sweet birch, sugar maple, northern red oak, silver bell, black cherry, American beech, yellow-poplar, and cucumber tree are most common.

Table III-2.--Some representative woody species of mixed mesophytic forests

Trees:

Common Name	Scientific Name
Black maple	*Acer nigrum*
Striped maple	*Acer pensylvanicum*
Red maple	*Acer rubrum*
Sugar maple	*Acer saccharum*
Yellow buckeye	*Aesculus octandra*
Downy serviceberry	*Amelanchier arborea*
Yellow birch	*Betula alleghaniensis*
Sweet birch	*Betula lenta*
American hornbeam	*Carpinus caroliniana*
Bitternut hickory	*Carya cordiformis*
Pignut hickory	*Carya glabra*
Shagbark hickory	*Carya ovata*
Mockernut hickory	*Carya tomentosa*
American chestnut	*Castanea dentata*
Eastern redbud	*Cercis canadensis*
Flowering dogwood	*Cornus florida*
Common persimmon	*Diospyros virginiana*
American beech	*Fagus grandifolia*
White ash	*Fraxinus americana*
Carolina silverbell	*Halesia carolina*
American holly	*Ilex opaca*
Butternut	*Juglans cinerea*
Black walnut	*Juglans nigra*
Sweetgum	*Liquidambar styraciflua*
Yellow poplar	*Liriodendrun tulipifera*
Cucumber tree	*Magnolia acuminata*
Fraser magnolia	*Magnolia fraseri*
Bigleaf Magnolia	*Magnolia macrophylla*
Umbrella magnolia	*Magnolia tripetala*
Red mulberry	*Morus rubra*
Black tupelo, blackgum	*Nyssa sylvatica*
Hophornbeam	*Ostrya virginiana*
Sourwood	*Oxydendrum arboreum*
Black cherry	*Prunus serotina*
White oak	*Quercus alba*
Scarlet oak	*Quercus coccinea*
Southern red oak	*Quercus falcata*
Blackjack oak	*Quercus marilandica*
Chestnut oak	*Quercus prinus*
Northern red oak	*Quercus rubra*
Post oak	*Quercus stellata*
Black oak	*Quercus velutina*
Black locust	*Robinia pseudoacacia*
Sassafras	*Sassafras albidum*
White basswood	*Tilia heterophylla*
Eastern hemlock	*Tsuga canadensis*
Shortleaf pine	*Pinus echinata*
Table mountain pine	*Pinus pungens*
Pitch pine	*Pinus rigida*
Eastern white pine	*Pinus strobus*
Loblolly pine	*Pinus taeda*
Virginia pine	*Pinus virginiana*

Shrubs and Vines:

Common Name	Scientific Name
Mountain maple	*Acer spicatum*
Devil's walking stick	*Aralia spinosa*
Dutchman's-pipe	*Aristolochia durior*
Paw paw	*Asimina triloba*
Azalea	*Azalea* sp.
Cross vine	*Bignonia capreolata*
American bittersweet	*Celastrus scandens*
Mountain pepperbush	*Clethra acuminata*
Alternate-leaf dogwood	*Cornus alternifolia*
American strawberry-bush	*Euonymus americanus*
Eastern burningbush	*Euonymus atropurpureus*
Black huckleberry	*Gaylussacia baccata*
Box huckleberry	*Gaylussacia brachycera*
Witch-hazel	*Hamamelis virginiana*
Wild hydrangea	*Hydrangea arborescens*
Mountain laurel	*Kalmia latifolia*
Common spicebush	*Lindera benzoin*
Virginia creeper	*Parthenocissus quinquefolia*
Oilnut	*Pyrularia pubera*
White rhododendron	*Rhododendron maximum*
Pink azalea	*Rhododendron nudiflorum*
Carolina buckthorn	*Rhamnus caroliniana*
Winged sumac	*Rhus copallina*
Elderberry	*Sambucus canadensis*
Cat greenbrier	*Smilax glauca*
Bristly greenbriar	*Smilax hispida*
Deerberry	*Vaccinium stamineum*
Lowbush blueberry	*Vaccinium vacillans*
Mapleleaf viburnum	*Viburnum acerifolium*
Arrowwood	*Viburnum dentatum*
Grape	*Vitis* spp.

Table III-3.--Some representative herbaceous species of mixed mesophytic forests

Common Name	Scientific Name	Common Name	Scientific Name
Common maidenhair	Adiantum pedatum	Galax	Galax aphylla
Rue anemone	Anemonella thalictroides	Rattlesnake plantain	Goodyera pubescens
Wood anemone	Anemone quinquefolia	Crested dwarf iris	Iris cristata
Jack-in-the-pulpit	Arisaema triphyllum	Ground cedar	Lycopodium digitatum
Blue wood aster	Aster cordifolius	Shining clubnoss	Lycopodium lucidulum
White wood aster	Aster divaricatus	Cinnamon fern	Osmunda cinnamomea
Glade fern	Athyrium pycnocarpon	Blue phlox	Phlox divaricata
Silvery glade fern	Athyrium thelypterioides	May-apple	Podophyllum peltatum
Rattlesnake fern	Botrychium virginianum	Christmas fern	Polystichum acrostichoides
Blue cohosh	Caulophyllum thalictroides	Bracken fern	Pteridium aquilinum
Spring-beauty	Claytonia virginica	Bloodroot	Sanguinaria canadensis
Southern fragile fern	Cystopteris protrusa	Goldenrods	Solidago spp.
Dwarf larkspur	Delphinium tricorne	Wood poppy	Stylophorum diphyllum
Hay-scented fern	Dennstaedtia punctilobula	New York fern	Thelypteris noveboracensis
Dutchman's breeches	Dicentra cucullaria	Painted trillium	Trillium undulatum
Fancy wood fern	Dryopteris intermedia	Violets	Viola spp.
White snakeroot	Eupatorium rugosum		

A recognizable feature of these forests is the presence of the colorful evergreen heaths and nonevergreen azaleas in understories. Examples of these shrubs include purple rhododendron, white rhododendron, mountain laurel, early azalea, and flame azalea. Other common understory species include striped maple, mountain maple, strawberry bush, and wild hydrangea.

Herbaceous species common to these forests include erect trillium, glade fern, foam flower, wild ginger, spotted wintergreen, butterfly weed, false aloe, hay scented fern, bleeding heart, and round-leaf yellow violet.

Southeastern spruce-fir forests grow at the highest elevations (greater than 4,500 feet) in North Carolina, Virginia, and Tennessee. These forests typically contain Fraser fir and red spruce overstories, with mountain maple, fire cherry, American mountain ash, hobblebush, and purple rhododendron understories. More comprehensive lists of woody and herbaceous species of Appalachian oak forests are found in tables III-4 and III-5.

(3) Oak-hickory-pine forests cover approximately 3 million acres (Federal, State, and private ownerships within counties that contain National Forest System lands). Many people recognize these as loblolly-shortleaf-hardwood forests. These forests form a transition zone that separates mountain hardwood forests from the lower Piedmont and Coastal Plain pine forests. They occupy the southern fringe of the Appalachians in the Table Plateaus, Ridge and Valley Lowlands, and Piedmont Upland Foothills of Alabama, Georgia, and South Carolina. They contain mixtures of pine and hardwood species. Braun (1950) classified these forests within parts of the oak-hickory, southeastern evergreen, and oak-pine forest regions, and Bailey (1980) classified them as part of the Southeastern Mixed Forest Province.

Loblolly, shortleaf, and Virginia pine predominate. Longleaf pine, a common species in the lower and middle Coastal Plain, does occur here in a more mountainous setting (up to approximately 2000 feet) in north Alabama. Hardwoods are codominant with pine throughout much of the area, and significant hardwood mid- and understories are characteristic of these forests. Most common are species of oak and hickory, along with dogwood, persimmon, sweetgum, elm, redcedar, yellow poplar, black tupelo, and red maple. Shrubs and vines common to these forests include American beautyberry, hawthorns, hollies, blueberries, viburnums, greenbriers, blackberry, trumpet creeper, honeysuckle, and grape. A more comprehensive list of woody and herbaceous species representative of the oak-hickory-pine forests is found in tables III-6 and III-7.

Table III-4.--Some representative woody species of Appalachian oak forests

Trees:

Common Name	Scientific Name	Common Name	Scientific Name
Fraser fir	*Abies fraseri*	Sourwood	*Oxydendrum arboreum*
Striped maple	*Acer pensylvanicum*	Red spruce	*Picea rubens*
Red maple	*Acer rubrum*	Shortleaf pine	*Pinus echinata*
Sugar maple	*Acer saccharum*	Table mountain pine	*Pinus pungens*
Yellow buckeye	*Aesculus octandra*	Pitch pine	*Pinus rigida*
Downy serviceberry	*Amelanchier arborea*	Eastern White pine	*Pinus strobus*
Sweetbirch	*Betula lenta*	Virginia pine	*Pinus virginiana*
Yellowbirch	*Betula lutea*	Fire cherry	*Prunus pensylvanica*
American hornbeam	*Carpinus caroliniana*	Black cherry	*Prunus serotina*
Bitternut hickory	*Carya cordiformis*	White oak	*Quercus alba*
Pignut hickory	*Carya glabra*	Scarlet oak	*Quercus coccinea*
Mockernut hickory	*Carya tomentosa*	Southern red oak	*Quercus falcata*
American chestnut	*Castanea dentata*	Blackjack oak	*Quercus marilandica*
Eastern redbud	*Cercis canadensis*	Chinkapin oak	*Quercus muehlenbergii*
Flowering dogwood	*Cornus florida*	Chestnut oak	*Quercus prinus*
American beech	*Fagus grandifolia*	Northern red oak	*Quercus rubra*
White ash	*Fraxinus americana*	Post oak	*Quercus stellata*
Mountain silverbell	*Halesia tetraptera* var. *monticola*	Black oak	*Quercus velutina*
		Black locust	*Robinia pseudoacacia*
Red cedar	*Juniperus virginiana*	Sassafras	*Sassafras albidum*
Yellow poplar	*Liriodendron tulipifera*	Linden	*Tilia heterophylla*
Cucumber tree	*Magnolia acuminata*	American basswood	*Tilia americana*
Black tupelo, black gum	*Nyssa sylvatica*	Eastern hemlock	*Tsuga canadensis*
Hophornbeam	*Ostrya virginiana*	American elm	*Ulmus americana*

Shrubs and Vines:

Common Name	Scientific Name	Common Name	Scientific Name
Mountain maple	*Acer spicatum*	White rhododendron	*Rhododendron maximum*
Dutchman's pipe	*Aristolochia durior*	Early azalea	*Rhododendron roseum*
New Jersey tea	*Ceanothus americanus*	Fragrant sumac	*Rhus aromatica*
Clematis	*Clematis virginiana*	Wild gooseberry	*Ribes rotundifolium*
Alternate-leaf dogwood	*Cornus alternifolia*	Bristly locust	*Robinia hispida*
Bush honeysuckle	*Diervilla lonicera*	Purple-flowering raspberry	*Rubus odoratus*
American strawberry bush	*Euonymus americanus*		
Witch-hazel	*Hamamelis virginiana*	Cat greenbrier	*Smilax glauca*
Wild hydrangea	*Hydrangea arborescens*	Common greenbriar	*Smilax rotundifolia*
Shrubby St. John's wort	*Hypericum spathulatum*	American mountain-ash	*Sorbus americana*
Mountain laurel	*Kalmia latifolia*		
Common spicebush	*Lindera benzoin*	Lowbush blueberry	*Vaccinium pallidum*
Japanese honeysuckle	*Lonicera japonica*	Deerberry	*Vaccinium stamineum*
Partridgeberry	*Mitchella repens*	Mapleleaf viburnum	*Viburnum acerifolium*
Mountain ash	*Pyrus americana*	Hobblebush	*Viburnum alnifolium*
Carolina buckthorn	*Rhamnus caroliniana*	Arrowwood	*Viburnum dentatum*
Flame azalea	*Rhododendron calendulaceum*	Blackhaw	*Viburnum prunifolium*
Purple rhododendron	*Rhododendron catawbiense*	Summer grape	*Vitis aestialis*
		Fox grape	*Vitis labrusca*

Table III-5.--Some representative herbaceous species of Appalachian oak forests

Common Name	Scientific Name	Common Name	Scientific Name
Common maidenhair	*Adiantum pedatum*	Rattlesnake plantain	*Goodyera pubescens*
Goat's-beard	*Aruncus dioicus*	Thyme-leaved bluet	*Houstonia serpyllifolia*
Wild ginger	*Asarum canadense*	Broad-leaf waterleaf	*Hydrophyllum canadense*
Four-leaved milkweed	*Asclepias quadrifolia*	Bush-clovers	*Lespedeza* spp.
Butterfly weed	*Asclepias tuberosa*	Shining clubnoss	*Lycopodium lucidulum*
White wood aster	*Aster divaricatus*	Wild lily-of-the-valley	*Maianthemum canadense*
Aromatic aster	*Aster oblongifolius*	Indian cucumber-root	*Medeola virginiana*
False goats'-beard	*Astilbe biternata*	Wild bergamot	*Monarda fistulosa*
Glade fern	*Athyrium pycnocarpon*	True wood-sorrel	*Oxalis montana*
Silvery glade fern	*Athyrium thelypteroides*	Purple phacelia	*Phacelia bipinnatifida*
Blue cohosh	*Caulophyllum thalictroides*	Broad beechfern	*Phegopteris hexagonoptera*
Spotted wintergreen	*Chimaphila maculata*	Solomon's seal	*Polygonatum biflorum*
Black snakeroot	*Cimicifuga racemosa*	Lyre-leaved sage	*Salvia lyrata*
Spring beauty	*Claytonia virginica*	Bloodroot	*Sanguinaria canadensis*
Brittle bladderfern	*Cystopteris protrusa*	Great chickweed	*Stellaria pubera*
Hayscented fern	*Dennstaedtia punctilobula*	Foamflower	*Tiarella cordifolia*
Tick-trefoils	*Desmodium* spp.	Erect trillium	*Trillium erectum*
Squirrel-corn	*Dicentra canadensis*	Large-flowered bellwort	*Uvularia grandiflora*
Yellow mandarin	*Disporum lanuginosum*	Canada violet	*Viola canadensis*
Marginal shield fern	*Dryopteris marginalis*	Round-leaf yellow violet	*Viola rotundifolia*
Dog-tooth violet	*Erythronium americanum*		
Galax	*Galax aphylla*		

Table III-6.--Some representative woody species of oak-hickory-pine forests

Trees:

Common Name	Scientific Name	Common Name	Scientific Name
Red Maple	*Acer rubrum*	Sourwood	*Oxydendrum arboreum*
American hornbeam	*Carpinus caroliniana*	Shortleaf pine	*Pinus echinata*
Bitternut hickory	*Carya cordiformis*	Longleaf pine	*Pinus palustris*
Pignut hickory	*Carya glabra*	Loblolly pine	*Pinus taeda*
Shagbark hickory	*Carya ovata*	Virginia pine	*Pinus virginiana*
Mockernut hickory	*Carya tomentosa*	Black cherry	*Prunus serotina*
Eastern redbud	*Cercis canadensis*	White oak	*Quercus alba*
Flowering dogwood	*Cornus florida*	Scarlet oak	*Quercus coccinea*
Common persimmon	*Diospyros virginiana*	Southern red oak	*Quercus falcata*
American beech	*Fagus grandifolia*	Blackjack oak	*Quercus marilandica*
White ash	*Fraxinus americana*	Chestnut oak	*Quercus prinus*
Eastern redcedar	*Juniperus virginiana*	Northern red oak	*Quercus rubra*
Sweetgum	*Liquidambar styraciflua*	Shumard oak	*Quercus shumardii*
Yellow-poplar	*Liriodendron tulipifera*	Post oak	*Quercus stellata*
Red mulberry	*Morus rubra*	Black oak	*Quercus velutina*
Black tupelo, Blackgum	*Nyssa sylvatica*	Sassafras	*Sassafras albidum*
Hophornbeam	*Ostrya virginiana*	Winged elm	*Ulmus alata*

Shrubs and Vines:

Common Name	Scientific Name	Common Name	Scientific Name
Serviceberry	*Amelanchier arborea*	Poison oak	*Rhus toxidodendron*
American beautyberry	*Callicarpa americana*	Blackberry	*Rubus* spp.
Trumpet creeper	*Campsis radicans*	Cat greenbrier	*Smilax glauca*
Fringetree	*Chionanthus virginicus*	Common greenbrier	*Smilax rotundifolia*
Hawthorns	*Crataegus* spp.	Common sweetleaf	*Symplocus tinctoria*
Climbing hydrangea	*Decumaria barbara*	Sparkleberry	*Vaccinium arboreum*
Winterberry, possumhaw	*Ilex decidua*	Deerberry	*Vaccinium stamineum*
American holly	*Ilex opaca*	Lowbush blueberry	*Vaccinium vacillans*
Japanese honeysuckle	*Lonicera japonica*	Arrowwood	*Viburnum dentatum*
Virginia creeper	*Parthenocissus quinquefolia*	Possumhaw viburnum	*Viburnum nudum*
		Rusty blackhaw	*Viburnun rufidulum*
Shining sumac	*Rhus copallina*	Summer grape	*Vitis aestivalis*
Smooth sumac	*Rhus glabra*	Muscadine grape	*Vitis rotundifolia*
Poison ivy	*Rhus radicans*		

Table III-7.--Some representative herbaceous species of oak-hickory-pine forests

Common Name	Scientific Name	Common Name	Scientific Name
Broomsedge bluestem	*Andropogon virginicus*	Yellow star-grass	*Hypoxis hirsuta*
White milkweed	*Asclepias variegata*	Bush-clovers	*Lespedeza* spp.
Brownstem spleenwort	*Asplenium platyneuron*	Blazing-star	*Liatris graminifolia*
Asters	*Aster* spp.	Hairy phlox	*Phlox amoena*
Yellow false-indigo	*Baptisia tinctoria*	Cinquefoil	*Potentilla canadensis*
Partridge-pea	*Cassia nictitans*	Bracken fern	*Pteridium aquilinum*
Spotted wintergreen; pipsissewa	*Chimaphila maculata*	Dollar-weed	*Rhynchosia reniformis*
		Blackeyed Susan	*Rudbeckia hirta*
Leather-flower	*Clematis reticulata*	White-top aster	*Sericocarpus asteroides*
Tickseed	*Coreopsis major*	Little bluestem	*Schizachyrium scoparium*
Tick-trefoils	*Desmodium* spp.	Pinehill bluestem	*Schizachyrium scoparium* var. *divergens*
Button-snake root	*Eryngium yuccifolium*		
Dogfennel	*Eupatorium capillifolium*	Sensitive-brier	*Schrankia microphylla*
Cottonweed	*Froelichia floridana*	Goldenrods	*Solidago* spp.
Downy rattlesnake-plantain	*Goodyera pubescens*	Pencil-flower	*Stylosanthes biflora*
		Goat's-rue	*Tephrosia virginiana*
Narrow-leaved sunflower	*Helianthus angustifolius*	Spikegrasses	*Uniola* spp.
Rattlesnake weed	*Hieracium venosum*	Woods vetch	*Vicia hugeri*

b. Appalachian Mountain Balds

Southern Appalachian mountain balds are meadow-like, essentially treeless openings of grasses, sedges, forbs, and shrubs that occur above 4,000 feet in elevation on mountain gaps, ridges, and crests.

Balds occur within spruce-fir and northern hardwood forest types of the Appalachian oak forest category. Tree species such as Fraser fir, red spruce, Eastern hemlock, yellow birch, sugar maple, red maple, serviceberry, black cherry, fire cherry, and American beech typically surround balds but are also found scattered in clumps or occur individually within balds.

Balds differ from one another. Assessing grassy balds of the Great Smoky Mountains National Park, Stratton and White (1982) noted that vegetation on grassy balds is not homogeneous. Elevation, type of forest surrounding the bald, unique site-specific characteristics, and history of disturbance determine the diversity of species found on each bald. Two types of balds are most commonly recognized: (1) grassy balds, and (2) heath balds (Mark 1959; Peterson 1980; Wells 1937; and Whittaker 1956).

Grassy balds, also called meadows, are open areas dominated by a variety of herbaceous species. The most characteristic species is mountain oat grass (*Danthonia compressa*). Other herbaceous species include autumn bent grass (*Agrostis perennans*), timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), bluet (*Houstonia serpyllifolia*), angelica (*Angelica triquinata*), dwarf cinquefoil (*Potentilla canadensis*), three-toothed cinquefoil (*P. tridentata*), wild strawberry (*Fragaria virginiana*), sheep sorrel (*Rumex acetosella*), sneezeweed (*Helenium autumnale*), plus various goldenrods (*Solidago* spp.), Pennsylvania sedge (*Carex pensylvanica*), phlox (*Phlox* spp.), and asters (*Aster* spp.).

In the absence of natural or man-caused disturbances, succession in grassy balds slowly proceeds from herbaceous to woody species (Great Smokey Mountains Uplands Field Research Laboratory 1983; Pittillo 1980). The most common woody species that encroach upon grassy balds are blackberries (*Rubus canadensis*, *R. allegheniensis*), blueberries (*Vaccinium corymbosum*, *V. vacillans*, *V. virgatum*), hawthorns (*Crataegus* spp.), various rhododendrons (*Rhododendron* spp.), and mountain laurel (*Kalmia latifolia*).

Woody succession has been estimated to be reducing the area of grassy balds by approximately one percent per year (Lindsay and Bratton 1979a). Bratton and White (1980) estimated that all balds in the Great Smoky Mountain National Park would be forested in 30 to 70 years. They concluded that management to retain grassy balds would involve utilization of a variety of methods that would change over time on a particular area.

Heath balds, also called slicks, are openings dominated by clumps or thickets of predominantly evergreen shrub species. Woody species of heath balds include purple rhododendron (*Rhododendron catawbiense*), white rhododendron (*Rhododendron maximum*), mountain laurel (*Kalmia latifolia*), highbush blueberry (*Vaccinium corymbosum*), mountain winterberry (*Ilex monticola*), southern mountain-cranberry (*Vaccinium erythrocarpum*), flame azalea (*Rhododendron calendulaceum*), wild gooseberry (*Ribes rotundifolium*), and black chokeberry (*Pyrus melanocarpa*). Herbaceous understory species found beneath these dense thickets include mountain oat grass (*Danthonia compressa*), galax (*Galax aphylla*), angelica (*Angelica triquinata*), painted trillium (*Trillium undulatum*), wintergreen (*Gaultheria procumbens*), and bracken fern (*Pteridium aquilinum*).

Mountain bald ecosystems provide habitat for Blue Ridge goldenrod (*Solidago spithamea*), which is listed by the Federal government as a "threatened" species, and other sensitive plants such as Fernald's hay sedge (*Carex aenea*), Canada lily (*Lilium canadense*), and green alder (*Alnus crispa*). Sensitive birds such as the golden eagle (*Aquila chrysaetos*) and the common raven (*Corvus corvax*) also utilize these areas. For a more complete list of Federally proposed, threatened, endangered, and sensitive plant and animal species, see appendix F.

Many theories have been developed over the last 50 years to explain the origin of these open areas. Theories include those of natural causes such as lightning fires, insects, windthrow, landslides, exposure to high winds and cold temperatures, changes in the climate, and ecotonal position; or man-caused activities such as clearing by Indians and early settlers (Great Smokey Mountains Uplands Field Research Laboratory 1983). Although questions about origin are unresolved, historically many of these areas have remained open due to environmental conditions, burning, and extensive grazing of cattle, horses, and to a lesser extent, sheep.

More detailed descriptions of plant and animal communities and associations of bald ecosystems, their history, and theories regarding their origin can be found in publications by Brown (1941), Cain (1930), Gersmehl (1970), Lindsay and Bratton (1980), McLeod (1988), Ramseur (1960), Robinson (1980), Stratton and White (1982), and Wells (1937).

Approximately 7,314 acres of land classified as southern Appalachian mountain balds occur on the Cherokee, Nantahala, Pisgah, and Jefferson National Forests. Of these, grassy balds occupy approximately 6,963 acres, while heath balds occupy 282 acres, and 69 acres are considered bald areas that are now forested. Some of the more well-known areas include Whitetop Mountain and Elk Garden on the Mt. Rogers National Recreation Area, Jefferson National Forest; Standing Indian on the Nantahala National Forest; Big Bald Mountain on the Cherokee and Pisgah National Forests; and Roan Mountain on the Pisgah National Forest. Additional balds can be found in the Great Smoky Mountains National Park and on private lands.

The Forest Service recognizes the recreational, natural, and scientific value of balds and has set direction for their management in Forest Service Manual 2362 9/84, Supplement No. 44, and in Forest Land and Resource Management Plans. Objectives of this management are to:

1. Ensure reestablishment or perpetuation of the often-unique vegetative character of these areas for a variety of national forest uses and purposes.

2. Provide a significant visual resource for recreationists to enjoy as well as special habitat requirements for unusual plant and animal life.

3. Provide the necessary survival needs for protection of endangered, threatened, and sensitive species occurring on certain balds.

c. Wilderness

There are 745,883 acres of wilderness in the Appalachian Mountains. Wilderness areas vary in size from 2,450 to 37,102 acres. The wilderness system includes hardwood river bottoms from the Bankhead National Forest of Alabama to high peaks and balds along the top of the Appalachians in Tennessee, North Carolina, and Virginia. A wide variety of plants and animals occupy these wilderness areas.

Vegetation management is not generally practiced in wilderness areas, but natural or prescribed fire may be necessary to ensure protection of rare and endangered species and reduce unnatural fuel buildups. Other vegetation management practices are minor.

d. Fire Management and Fuel Types

Periodic natural and man-caused fires have heavily influenced Appalachian forests. Loblolly, shortleaf, longleaf, Virginia, pitch, and table mountain pine are fire-dependent subclimax species which are naturally maintained by fire. These pines and some hardwoods, such as fire cherry, yellow-poplar, and some upland oaks, have adapted to periodic burning regimes (appendix E).

Lightning fires are not frequent or intense enough to maintain these species on most sites, so fires set by Indians and settlers probably perpetuated such stands. Fire protection since the 1920's has greatly reduced fire's role in Appalachian forests. Rhododendron and mountain laurel thickets have increased, and oak stands and fire-dependent ecosystems have declined (appendix E).

Today, fire management is used to reduce hazardous fuels, control understory hardwoods in pine stands, prepare sites for pine and hardwood regeneration, protect fire-dependent species and ecosystems, and improve wildlife habitat. Average annual acres treated by prescribed fire on Appalachian national forests are:

1. Hazardous Fuels ------------------------ 23,000
2. Wildlife Habitat ------------------------ 14,900
3. Site Preparation ------------------------ 5,500
4. Timber Stand Improvement ---------------- 400
5. Ecosystem Maintenance (balds, etc.) ----- 1,000

Climate and physiography of the Appalachians support seven major fuel types with differing burning characteristics. Fire intensity in any fuel type varies greatly with topography, weather (rainfall, humidity, wind), and the amount, size distribution, degree of concentration, moisture content, and chemistry of available fuels. In general, more fuels become available during periods of low live fuel moisture, as in fall and winter when vegetation is dormant or in spring and summer droughts. The major fuel types are:

a. Hardwood on damp coves to dry ridges. Available fuels can include leaves, forbs, decaying woody material, humus, and evergreen heaths such as rhododendron and mountain laurel. Fuel loads are generally low and support low-intensity surface fires. Because moisture varies so much across the array of landforms, fuels may burn on ridges when they cannot burn on lower slopes and coves.

b. Pine including natural pine stands and pine plantations (after crown closure) mostly on dry sites, and cedar on limestone terrain. Available fuels can include needle litter and scattered hardwood brush. Fuel loads are moderate and normally support rather slow-moving, low- to medium-intensity surface fires.

c. Pine-hardwood on dry to damp sites. Overstory is pine or mixed pine-hardwood with hardwood understory. Available fuels can include needle and leaf litter, grass, forbs, decaying woody material, and evergreen hardwoods. Fuel loads are generally high in natural stands and support medium-intensity surface fires.

d. Pine-rhododendron/laurel mostly on dry ridges and south to west slopes. Pines dominate the overstory and evergreen heaths the understory. Available fuels can include forbs, needle litter, dense rhododendron/mountain laurel thickets, and other brush. Fuel loads and flammability can be high, often supporting intense surface fires burning into crowns.

e. *Spruce-fir* at high altitudes in the Blue Ridge and Unaka mountains and Ridge and Valley Highlands. Available fuels can include needle litter, grass, moss, and evergreen understory. Fires are normally slow moving and low-intensity due to cool, moist conditions. During droughts when moss is dry and flammable, fires can spread into low spruce-fir crowns with high intensity.

f. *Grass* including mountaintop balds in the Blue Ridge and Unaka mountains and open pine plantations. Available fuels can include grass, forbs, and hardwood brush. Low- to medium-intensity surface fires move rapidly and often involve pine foliage in plantations.

g. *Logging slash* associated with harvest cuts and thinnings. Available fuels can include all living, dead, and cut down plant materials. Fires can be very intense if slash is heavy, concentrated, and dry.

2. Wildlife

Appalachian Mountains ecosystems support a great variety of terrestrial life. This variety reflects the wide range of climatic conditions, elevation, forest types, and successional stages on national forests.

Big-game species include white-tailed deer (*Odocoileus virginianus*), eastern wild turkey (*Meleagris gallopavo*), and black bear (*Ursus americanus*). Important small-game species are bobwhite quail (*Colinus virginianus*), eastern mourning dove (*Zenaida macroura*), cottontail rabbit (*Sylvilagus floridanus*), gray (*Sciurus carolinensis*) and fox squirrel (*Sciurus niger*), ruffed grouse (*Bonasa umbellus*), several species of waterfowl, and American woodcock (*Scolopax minor*). Major fur-bearing species include raccoon (*Procyon lotor*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes fulva*), and bobcat (*Lynx rufus*). Thousands of other species of birds, mammals, reptiles, amphibians, and invertebrates also live in or near the national forests.

The Forest Service and cooperating State wildlife agencies routinely manage habitat for game and nongame wildlife. State wildlife agencies are responsible for establishing wildlife management regulations and enforcement. These efforts are integrated and coordinated through cooperative programs of the Forest Service and other agencies and involve active management of wildlife habitat by cooperators, particularly State Wildlife Resource Agencies.

3. Threatened Endangered, Proposed and Sensitive Species

Twenty-six animal species classified by the U.S. Fish and Wildlife Service as *threatened* or *endangered* (or *proposed* for listing as threatened or endangered) live in Appalachian Mountain national forests. These species include five mammals, three birds, one reptile, six fish, and ten mollusks. Seven plant species with Federally threatened, endangered, or proposed status occur. Habitats of these species are managed under authority of the Endangered Species Act with the goal of population recovery. Appendix F lists these species and describes their habitats.

In addition, certain species for which population viability is a concern are designated by the Regional Forester as sensitive. Normally, this designation is established with concurrence and guidance of the appropriate State Heritage Agency. Habitats of sensitive species are managed to ensure population levels which keep these plants and animals from becoming threatened or endangered. Appendix F lists species currently designated as sensitive and describes their habitats.

4. Soils

Soils of the Appalachians vary with geology, climate, and topography. Five soil orders occur in significant amounts.

a. Ultisols are highly developed acid soils with strong clay buildup in subsoil and intense leaching of bases. These loamy to clayey soils are usually rather deep and contain few rock fragments. They are most common on ridges and sideslopes and are the dominant soil order throughout the Appalachians.

b. Inceptisols are poorly developed, acid, loamy soils. Two groups are dominant. Those on ridges and sideslopes are often shallow and rocky with thin topsoil and little clay buildup in subsoil. Those in coves and floodplains are usually deep with thick topsoil and weak subsoil.

c. Alfisols are well-developed neutral soils with some clay buildup in subsoil and slight leaching of bases. These loamy to clayey soils usually are rather deep and may be rocky. They are most common on limestone coves, terraces, and benches in the Ridge and Valley province and the Cumberland Plateau.

d. Entisols are undeveloped, acid, loamy soils. They occur in floodplains and are often deep with thick topsoil and very weak or no subsoil.

e. Mollisols are well-developed neutral soils high in organic matter with some clay buildup in subsoil and slight leaching of bases. These loamy to clayey soils are usually rather deep and contain few rock fragments. They occur on grassy hills or coves and terraces over limestone in the Cumberland Plateau.

Productivity of these soils depends much on their geology, topography, and land-use history. Inceptisols on ridges and sideslopes are often unproductive due to limited moisture storage and low fertility. Ultisols are rather productive, more so on wetter north-east and lower slopes. Mollisols and alfisols developed on limestone are productive. Inceptisols and entisols in coves and floodplains are enriched in moisture and nutrients deposited from upslope and upstream, and are the most productive soils.

Soils severely eroded or disturbed by past farming, mining, or logging may be seriously deficient in organic matter and nutrients, most of which occur in topsoil. Soils developing in coal mine spoil in the Appalachian Plateaus province are typically rocky, acid, and infertile.

Erosion hazard increases with slope steepness and is generally highest on weakly cemented or mica-rich soils. Landslide hazard is highest on steep slopes with shallow or weakly cemented soils. Compaction hazard is highest in clayey soils and in poorly drained floodplains and coves.

5. Water and Aquatic Life

The humid Appalachian climate produces abundant water. Annual runoff is 10-25 inches in Virginia and Kentucky, 25-45 inches in the Blue Ridge and Unaka mountains, and up to 50-60 inches in some high watersheds. Streamflows are usually highest in winter and early spring and lowest in late summer and fall.

a. Surface Water

National forests contain about 14,400 miles of perennial streams, nearly 75 percent of which occur in the Blue Ridge province. Intermittent streams are common in the Ridge and Valley province. Natural lakes are rare, but the Blue Ridge province has many large reservoirs. The Ridge and Valley province also has many small impoundments, and the Appalachian Plateaus province has some of each.

Surface water quality is excellent, except in some polluted streams or during major storms. Major sources of chemical pollution are coal mines and oil and gas sites in the Appalachian Plateaus and pyrite-rich rocks in the Unaka Mountains that can produce acid runoff. Major sources of sediment are mines, roads, farms, and construction sites.

In the Blue Ridge province, steep slopes and dense stream networks create a very high potential for increased erosion and sediment loads. Floodplains are narrow. Streambeds are bedrock and large, rounded gravels mixed with sand. Igneous and metamorphic rocks produce surface water that is neutral and low in dissolved minerals.

In the Ridge and Valley province, moderately steep slopes and dense stream networks create a high potential for increased erosion and sediment loads. Floodplains are narrow in uplands and wide in lowlands. Streambeds are bedrock and small, platy gravels mixed with sand. Shale and limestone produce surface water that is neutral to basic and high in dissolved minerals.

In the Appalachian Plateaus province, moderate slopes and stream densities create moderate potential for increased erosion and sediment loads. Floodplains are narrow. Streambeds are bedrock and large, rounded gravels mixed with sand. Sandstone produces surface water that is acid and low in dissolved minerals. Streams draining coal-mined areas are often very acidic.

b. Aquatic Life

Diverse aquatic habitats of the Appalachians support over 400 species of fish, reptiles, amphibians, mollusks, and aquatic insects. The 4 basic habitat types are rivers, streams, lakes/reservoirs, and ponds. Each can be affected by forest management, with sediment and chemicals having the most harmful effects.

Rivers contain the greatest diversity of species. Smallmouth bass (*Micropterus dolomieui*), channel catfish (*Ictalurus punctatus*), and walleye (*Stizostedion vitreum*) are popular cool and warm water sport fish. Coldwater habitat for brown trout (*Salmo trutta*) and rainbow trout (*Salmo gairdneri*) occur below hydroelectric dams. Rivers also contain many rare types of freshwater mussels.

The 5,600 miles of coldwater streams support brook (*Salvelinus fontinalis*), brown, and rainbow trout; blacknose dace (*Rhinichthys atratulus*); and creek chub (*Semotilus atromaculatus*). Aquatic insects are the food base for these fish. Some, such as mayfly (*Ephemerella doddsi*), stonefly (*Pteronarcys californica*), and caddisfly (*Rhyaccophila* species) are sensitive to minor changes in water quality. Coldwater streams occur mainly in the Blue Ridge province, Ridge and Valley Highlands, and Cumberland Mountains.

The 8,800 miles of warmwater streams support rock (*Ambloplites rupestris*) and smallmouth bass and northern hogsucker (*Hypentelium nigricans*). Warmwater streams occur mainly in the Ridge and Valley Lowlands and Cumberland Plateau. Many declining populations of darters and madtoms occur in streams.

The 26,000 acres of lakes and reservoirs support striped bass (*Morone saxatilis*), black crappie (*Pomoxis nigromaculatus*), and yellow perch (*Perca flavescens*). Gizzard shad (*Dorosoma cepedianum*) is a forage fish that sustains these game species. Some reservoirs experience temperature layering and support coldwater species in addition to these warmwater species.

Ponds contain bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*). Some natural ponds support the rare shovelnose salamander (*Leurognathus marmoratus*) or bog turtle (*Clemmys muhlenbergi*).

c. Ground Water

Aquifers that yield high amounts of ground water are mostly confined to sandstone and limestone in the western Cumberland Plateau, limestone valleys in the Ridge and Valley province, and some fractured granite and gneiss in the Blue Ridge province. Valley deposits of some rivers are also productive aquifers. Other areas yield little water, so most use comes from surface sources. Ground water is high in iron in many areas, and is most readily contaminated in limestone karst terrain with sinking creeks, sinkholes, and caverns. Dissolved mineral content of ground water is low in the Blue Ridge province, moderate in the Appalachian Plateaus province, and high in the Ridge and Valley province.

d. Wetlands

Wetlands occupy less than 2,000 acres in floodplains and a few high mountain bogs. Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) protect the flood-moderating value of floodplains and the ability of wetlands to produce abundant and diverse biota, regulate water flow and quality, and recharge ground water.

6. Air

In the dormant season, air flow and quality are dominated by migrating, frequently changing air masses and storm systems. In the growing season, air flow and quality are dominated by the Atlantic high-pressure system whose clockwise movement pumps in tropical air from the Gulf of Mexico. Prevailing winds are typically from the northwest from October to March, and from the southwest from April to September.

Air quality is generally good in winter and spring when rapidly changing weather patterns tend to keep the atmosphere well mixed. Occasional stagnation periods in summer and fall cause natural and manmade pollutants to build up. Stagnation is worsened in valleys where pollutants are trapped by surrounding hills and nighttime downslope air flows. No major industrial centers occur in the area, but pollutants emanate from local sources including cities. Local pollution can be serious in populated valleys. Pollutants may also move into the area from long distances, and some may be important contributors to acid deposition at high elevations.

Geographic areas are typed as either Class I, II, or III. Class I areas are thought to have the best air quality and are mandated special protection. Air quality in Class II and III areas exceeds National Ambient Air Quality Standards set by the Environmental Protection Agency, but protection is not as stringent as in Class I areas. The Appalachian Mountains are all Class I or II. Ten Class I areas are potentially affected (table III-8 and figure III-2).

Table III-8.--Class I areas and jurisdictions

Class I Area	State	Responsible Agency
Cohutta Wilderness	GA-TN	USDA Forest Service
Dolly Sods Wilderness	WV	USDA Forest Service
Great Smoky Mountains National Park	NC-TN	USDI National Park Service
James River Face Wilderness	VA	USDA Forest Service
Joyce Kilmer-Slickrock Wilderness	NC-TN	USDA Forest Service
Linville Gorge Wilderness	NC	USDA Forest Service
Otter Creek Wilderness	WV	USDA Forest Service
Shenandoah National Park	VA	USDI National Park Service
Shining Rock Wilderness	NC	USDA Forest Service
Sipsey Wilderness	AL	USDA Forest Service

Eight wildernesses (table III-8) are managed by the Forest Service. Two national parks occur within 60 miles of national forests and could be affected by management actions. Other potentially affected areas are highways, airports, and populated areas downwind from national forests

7. **Rights-of-Way Corridors**

Rights-of-way include roads, trails, utility corridors, and railroads. Historically, vegetation management programs for rights-of-way maintenance have included the full range of

options including manual, mechanical, biological, fire, and herbicides.

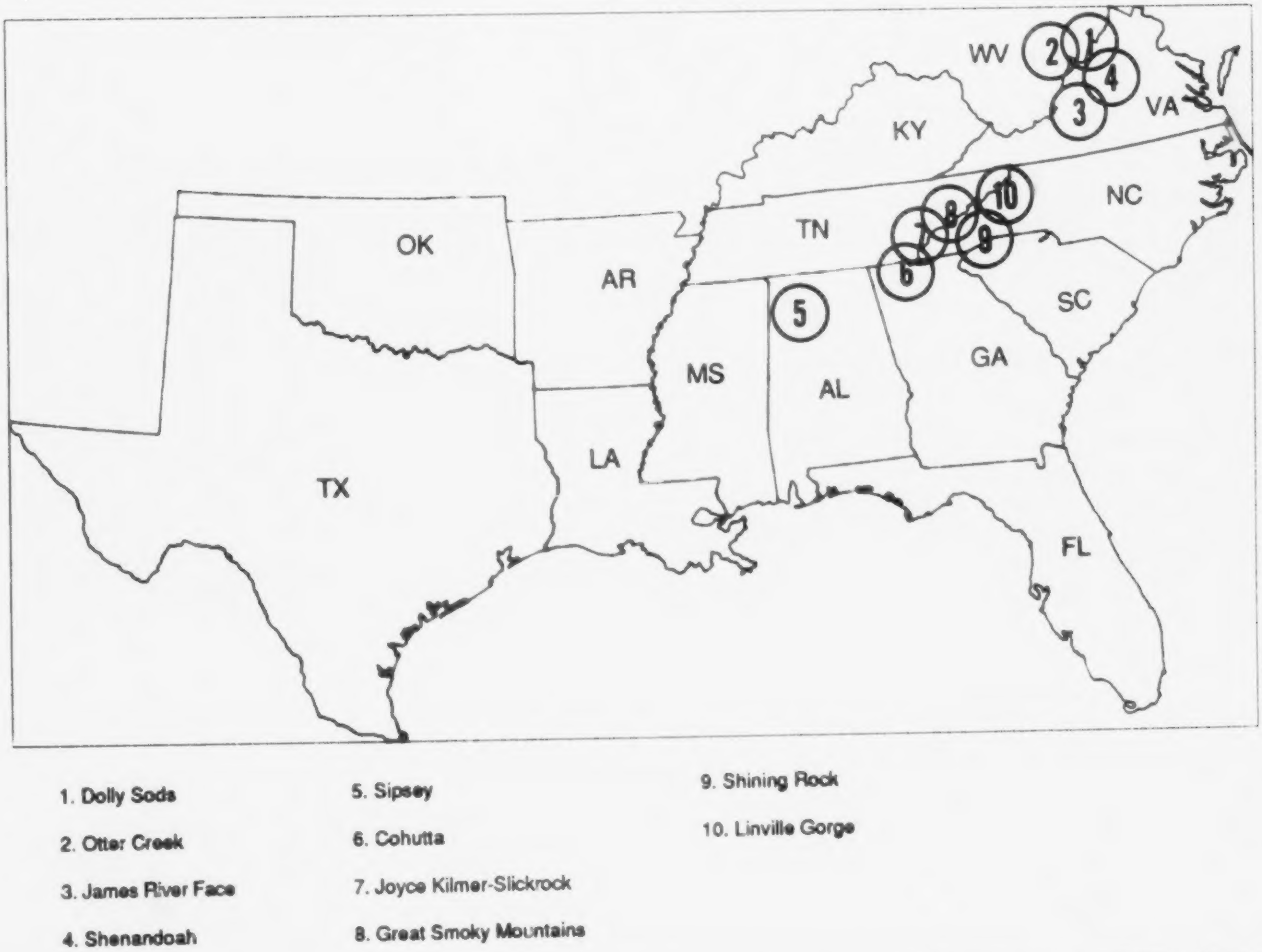
a. Roads

Roadside vegetation is managed to protect investment and to provide user safety in concert with the road's intended use. Forest Service roads in the Appalachian Mountains total 8,950 miles. Using mostly mechanical methods, crews maintain about 10,700 acres of vegetation along roads to one of five levels. Amount of traffic and maintenance requirements increase with each level:

Maintenance Level	Miles
1	1,050
2	4,300
3	2,050
4	1,100
5	450
Total	8,950

Roads and highways maintained by other Federal, State, and county agencies under special use permit with the Forest Service total 325 miles, requiring 3,900 acres of maintenance. Vegetation management is performed on road

Class 1 Areas


WV
VA
KY
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7
8
9
10
1. Dolly Sods
2. Otter Creek
3. James River Face
4. Shenandoah
5. Sipsey
6. Cohutta
7. Joyce Kilmer-Slickrock
8. Great Smoky Mountains
9. Shining Rock
10. Linville Gorge

Figure III-2.--Class I areas.

shoulders to enhance drainage; on cut and fill slopes to provide increased sight distance; and along roadsides to control danger trees.

b. Trails

Trails provide outdoor recreation opportunities and access to scenic and cultural resources. Trailside vegetation is controlled to provide for user safety, protect the investment, and enhance trailside appearance. Manual and mechanical methods are chiefly used.

Hiking, off-road vehicle (ORV), horse, and canoe trails mak up the 5,290 miles of trail that require vegetation management. The bulk of this mileage is hiking trails, although horseback and ORV trails are maintained.

c. Utility Corridors

Many powerline and communication utilities have above-groun and buried cable lines through national forests. Vegetatio management is performed along these areas to enhance transmission system reliability, provide public and worker safety, and access facilities. Some rights-of-way are maintained annually and others intermittently at up to 10-year intervals.

There are 1,300 miles of utility corridors of varying width that include 6,750 acres of national forest lands. About 1,350 acres are maintained each year. Vegetation control programs are used to keep trees from growing across conductors, thus preventing power outages, safety hazards, and possible forest fires from broken lines. Vegetation is also controlled along access roads. Manual, mechanical, an herbicide methods are used.

d. Railroads

Railroad transportation systems have rights-of-way, access roads, crossings, and communication facilities that require annual vegetation control on national forest lands. All methods may be used.

e. Pipelines

Vegetation controls are used annually on about 250 acres along 65 miles of oil and gas pipelines. These controls allow for detection of leaks, control of undesirable plants public and worker safety, and access. Mechanical, manual, and herbicide methods are used.

8. Visual Quality

The Appalachian Mountains form the eastern Continental Divide with elevations ranging from 500 to 6,700 feet and contain one of the most extensive hardwood forests in the world. Landscapes vary from rolling foothills to rugged, steep mountainous slopes. Many southern rivers and streams begin in these mountains. Prominent landscape features include lakes, whitewater streams, high mountain peaks, cliffs, and distinctive vegetative patterns with many varie deciduous and conifer species.

Inventoried visual quality levels are determined by "distance zone," the distance at which a landscape is viewed; "sensitivity level," the number and interest level of people viewing the scene; and "variety class," the interest and visual diversity a landscape affords.

A Visual Quality Objective (VQO)is assigned to each landscape which describes the degree of alteration permissible for each management situation. VQO's constitute a ranking which can be described as follows:

Increasing protection & enhancement of the natural landscape required ↑

1. Preservation VQO
2. Retention VQO
3. Partial Retention VQO
4. Modification VQO
5. Maximum Modification VQO

↓ Increasing alteration of the natural landscape permitted

9. Recreation

National Forests in the Appalachians have highly diversified landscapes, ranging from broad valleys with lakes and large rivers to narrow ridges and steep mountains with clear trout streams and waterfalls. These offer a wide range of developed and dispersed recreation opportunities such as camping, hiking, horseback riding, hunting, fishing, sightseeing, berrypicking, cross-country snow skiing, various water-related activities, and many others.

Developed recreation includes a range of facilities such as campgrounds, visitor centers, picnic areas, swimming, and boating sites. Dispersed recreation consists of activities that usually involve less interaction among users. Examples include hiking, hunting, off-road vehicles, horseback riding, canoeing, and fishing in undeveloped locations.

Vegetation management activities such as mowing grass, controlling poisonous plants and fire hazards, and removing hazard trees are performed in forest recreation areas to provide for public safety, improve visibility and access, and create and maintain a natural-looking environment.

There are about 9,050 acres of developed recreation sites where vegetation management is done. Annual use of these 760 developed Appalachian recreation sites is currently over 3.8 million Recreation Visitor Days (RVD's). A Recreation Visitor Day is defined as equal to 12 hours spent by one visitor. Use levels at developed sites will increase slightly in the future. About 15 percent of developed sites, or 1,350 acres, are treated annually.

Dispersed recreation use accounts for about 11 million RVD's in undeveloped dispersed recreation areas. Because of the nature of dispersed recreation, very little vegetation management is needed. While dispersed recreation will likely increase in the future, there will be a negligible increase in vegetation management for these recreation uses. One of the prominent features is the Appalachian National Scenic Trail (A.T.) of which 732 miles traverses across national forest lands in Virginia, Tennessee, North Carolina, and Georgia.

Vegetation management techniques used in recreation sites consist primarily of manual and mechanical means. Herbicides are used in minor amounts to treat toxic plants and weeds around parking barriers, fences and buildings. Fire is occasionally used to maintain grasses on dam sites and wildlife habitat associated with wildlife viewing areas.

10. Cultural Resources

Cultural resources are artifacts, buildings, or sites resulting from past human activity. They can be archaeological, historical, prehistoric, or architectural. Cultural resources are irreplaceable and of great concern to the public. Examples are remnants of old wagon roads, homesteads, Civilian Conservation Corps structures, or native American camp sites or mound complexes.

Laws and regulations require that Federal agencies manage the cultural resources under their control. Procedures are followed to assure that cultural values are considered in any decision-making process. These procedures include inventorying, evaluating, determining effects, and mitigating adverse effects.

In the Appalachian Mountains, 15 percent of the area has been inventoried at varied intensities for cultural resources. Approximately 1,260 historic and 3,358 prehistoric sites have been recorded through FY 1986.

11. Socioeconomics

Approximately 30.8 million people live in states containing national forests in the southern Appalachian mountains. Within the boundaries of these national forests are about 5.7 million acres of private land. Private landowners include year-round residents, summer residents, small businesses, absentee landowners, and a few industrial timber companies.

Population growth in the South has outpaced the nation's growth rate since 1970, and this trend is expected to continue through 1990. The southern Appalachian Mountains have not realized growth trends of many southern areas. Future population growth is projected to be less than the South as a whole. Prior to 1970, this section of the nation experienced population decline, especially in the adult population of childbearing years. Average age of the population is greater than in most other sections of the country due to young people having moved out prior to 1970 and to the influx of retirees. Population growth from 1975 to 1985 is primarily due to net in-migration (Dahmann 1986). Growth from in-migration is expected to continue (see table III-9).

Table III-9.--Population and population projections (Dahman, 1986)

State*	Population (thousands) 1977	Population (thousands) 1986	Population Projections (thousands) 1990	Population Projections (thousands) 2000
Alabama	3,691	4,052	4,214	4,415
Georgia	5,041	6,104	6,175	6,708
Kentucky	3,468	3,729	4,074	4,400
North Carolina	5,515	6,333	6,473	6,868
Tennessee	4,292	4,803	5,073	5,419
Virginia	5,095	5,787	5,961	6,389
Total	27,102	30,808	31,970	34,199

*Parts of South Carolina and West Virginia are included in the study area, but contain such small National Forest acreage that populations are not predicted.

Total employment in the Region has followed population trends, with 48 percent of the population employed in 1986 (48 percent participation ratio is slightly below the U.S. ratio of 50 percent). Employment by major sector follows national trends. The Region, however, shows slightly greater dependence on government employment. Also, the small amount of durable-goods manufacturing has allowed the South to be less influenced by recessionary pressures than the rest of the nation. The Region since the 1940's has escaped severe inventory corrections that cause unemployment (Haulk 1980). As a result, unemployment rates generally have been below national averages during periods of recession. Figure III-3 displays employment by major industry in the Southern Region, and table III-10 shows employment by major industries by State, 1983.

Agriculture and related services have declined in relative importance and account for less than 10 percent of total employment in the region. The decline has been more than offset by growth in the services sector. However, most rural counties, although they make up a small part of the total population, are still very dependent on agriculture and related services for employment.

Per capita income for the South historically has been below the national average. In 1983, it averaged $8,381, which is 12 percent below the national average. Wages and salaries earned in agricultural and light industrial occupations, predominant in the South, are lower than those earned in heavy manufacturing. Projections of per capita income reflect substantial increases at national and regional levels, with proportional gains in the South.

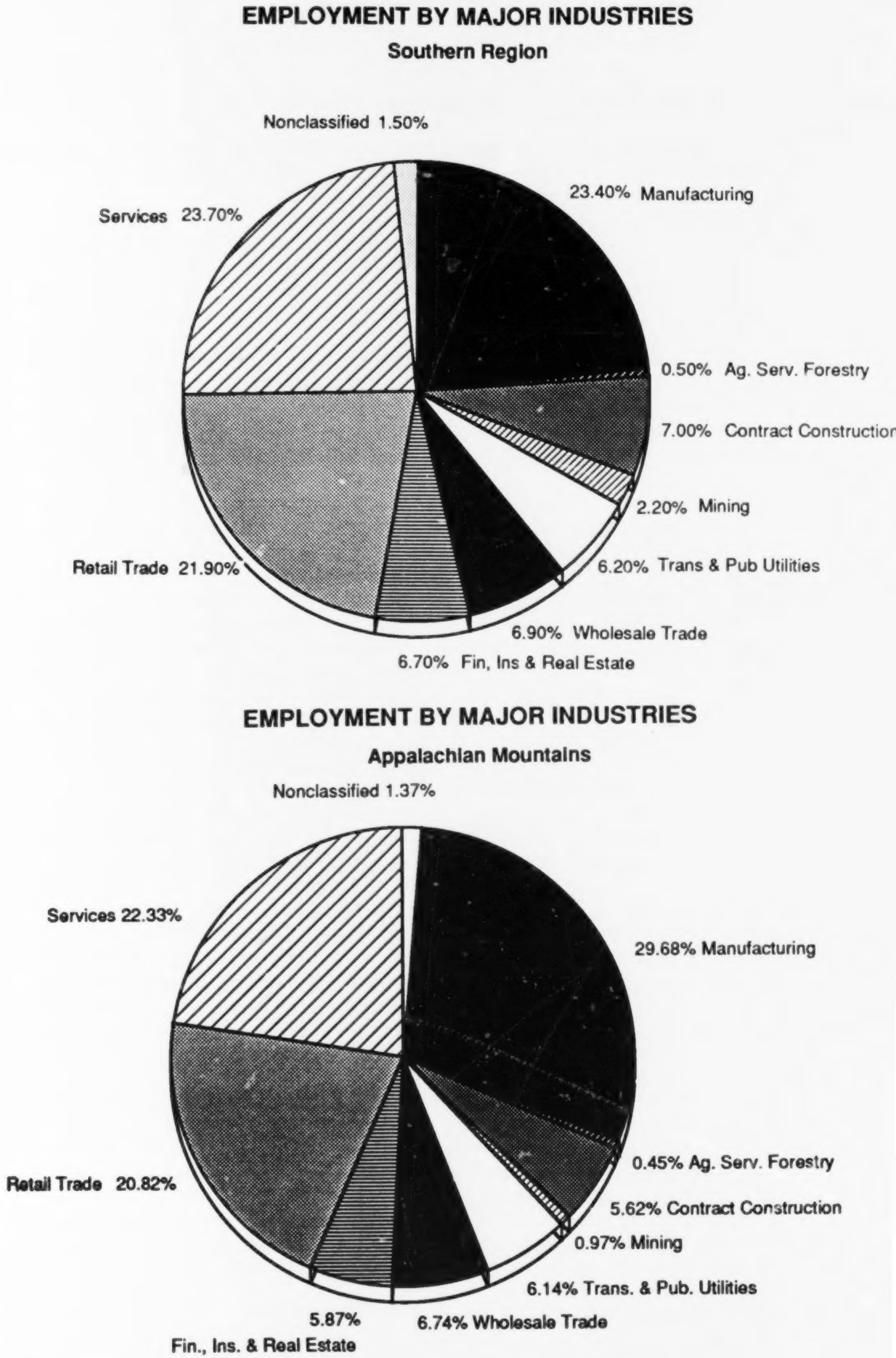

Figure III-3.--Employment by major industries (adapted from Bureau of Census

Table III-10.--Employment by major industries by State, 1983 (adapted from Bureau of Census data)

	AL	GA	KY	NC	TN	VA	TOTAL
Ag Serv For & Fisheries	4,798	10,776	4,668	9,731	5,108	8,796	43,877
Mining	34	7,826	41,757	3,468	8,031	19,980	95,096
Contract Construction	76,355	135,850	46,481	133,277	23,391	134,016	549,370
Manufacturing	340,772	560,624	254,418	840,496	486,162	420,836	2,903,308
Transport & Other Pub Util	68,637	150,174	53,903	127,677	82,582	117,335	600,308
Wholesale Trade	75,177	168,346	63,282	133,975	111,407	107,460	659,647
Retail Trade	228,238	442,438	223,465	421,175	311,340	410,103	2,036,759
Finance Ins & Real Estate	65,106	134,214	54,669	110,414	90,880	119,234	574,517
Services	37,663	447,783	225,711	412,369	362,042	498,095	2,183,664
Non-classified	3	28,315	19,623	27,296	20,841	22,824	130,482
TOTAL	1,126,363	2,086,346	987,977	2,219,878	1,501,784	1,858,679	9,777,028

Note: Parts of South Carolina and West Virginia are included in the study area but contain such small National Forest acreage that employment cannot be realistically predicted.

The South has traditionally depended on forest and range resources for goods and services. Current projections indicate that these resources will become more important in the future. Land managers recognize that effects of their actions extend far beyond national forests, and that they must be familiar with relationships between natural resource management and the social and cultural environment.

People who live and work in or near the national forests have diverse expectations of forests based on differing value systems. In general, long-term residents of these areas tend to value land use; they enjoy being surrounded by forests and believe in using forests to gather products suc as ginseng, galax, moss, and firewood. They also want to use forests for hunting and fishing, picnicking, boating, and swimming. Some value forests for their ability to produce tourism-related employment but others would prefer having the mountains and forests to themselves. Many long-term residents work in timber-related jobs or have relatives and friends who depend on this segment of the economy. They value the beauty of the mountains but are more likely to want to use forests than to preserve them. Some value the very existence of forests and need not visi them to derive satisfaction.

Newcomers, whether summer residents, year-round residents, or retirees, are more likely than long-term residents to value preservation of forests. They are less likely to gather forest products or to work in timber-related jobs. Hiking, backpacking, and viewing are more likely to be valued forms of recreation for this group. They value preservation of the visual beauty of their new surroundings. This group is increasing its representation in the area's population.

People's expectations of the forest are fulfilled through experiences. These experiences can be recreational, occupational, or just casually related to the daily living environment. Forest experiences occur in one of five kind of areas or settings which combine physical, biological, social, and managerial conditions (table III-11 lists acreage for each setting):

Table III-11.--Experience settings (Approximate [illegible]es)

Forest	P	SPNM	SPM	RN	R
Alabama		9,000	12,000	376,000	600
Chattahoocheee		89,000	37,000	615,000	
Cherokee	67,000	68,000	9,000	447,000	3,000
Daniel Boone		90,000	190,000	350,000	40,000
George Washington	33,000	251,000	154,000	617,000	
Jefferson		106,000	72,000	468,000	45,000
Nantahala/Pisgah		181,000		831,000	3,000
Sumter		2,000	2,000	22,000	52,000

Key: P - Primitive
SPNM - Semi-primitive non-motorized
SPM - Semi-primitive motorized
RN - Road natural
R - Rural

(1) Primitive experiences occur in areas which have extremely high probability of isolation from human activity with difficult access by foot, a closeness to nature, with a high degree of challenge and risk in a large area of unmodified natural environment. Management controls are primarily off-site.

(2) Semi-primitive, non-motorized experiences occur in areas which have high probability of isolation with a moderate to high degree of challenge and risk in a large area of natural or natural appearing environment with access by foot. Management controls may be present, but subtle.

(3) Semi-primitive, motorized experiences occur in areas which have moderate degrees of isolation, but some opportunity for vehicle use, risk, challenge and self-reliance in a predominately natural-appearing area of moderate size with limited access by road. Management controls are present with some dominant modifications.

(4) Roaded natural experiences occur in areas which have about equal probability of isolation and social contact. Challenge and risk are not often present. Some easily noticed dominant modifications occur, but management controls harmonize with the natural environment, with convenient access by road.

(5) Rural experiences occur in areas which have high probability for social interaction. Convenience is more important than challenge. Modifications are fairly constantly observed, controls are obvious and numerous, and access is designed for ease and comfort.

Vegetation management can enhance or impair these settings, and thus affect experiences. This evaluation groups forest users into workers and long-term residents, neighbors and newcomers, and visitors (table III-12).

The table shows some possible experiences for each group in each setting. Many experiences can be obtained in any setting and individuals can be members of different user groups at different times. Workers include employees, contractors, permittees, and cooperators. Long-term residents are those people who have spent most of a lifetime in the area. Many are second and third generation residents. Neighbors include adjacent landowners, permittees, and local community residents. Newcomers are those people who have recently moved to the area, but nevertheless reside here. Visitors are those who come to the forests for specific purposes, stay a short while (hours or days), then return home.

Table III-12.--Experiences by user groups in different settings

	USERS		
SETTING	Workers/Long-Term Residents (Types of Work)	Neighbors/Newcomers (Types of Benefits)	Visitors (Types of Activities)
Primitive	Trail maintenance	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, canoeing, tent camping, solitude, walking
Semi-Primitive Non-Motorized	Resource inventory, inspections, limited resource work	Viewing, solitude, vicarious benefits	Hiking, nature study, fishing, hunting, camping, horseback riding, canoeing, swimming, solitude, walking
Semi-Primitive Motorized	Cultural treatments, resource manipulation, enforcement	Vehicular access, viewing, contact with others, vicarious benefits	Nature study, fishing, hunting, camping, pleasure driving, off-road vehicle use, boating, riding, gathering products
Roaded Natural	Cultural treatments, resource control enforcement, maintenance of services, wide range of intensity of work	Vehicular access, viewing, frequent contact with others, gathering products, vicarious benefits	Fishing, hunting, camping with services, pleasure driving, off-road vehicle use, boating, riding, gathering products games and play, interpretive services, cycling, picnicking
Rural	Resource control, resource marketing, transportation, economy, high intensity work	Rural comfort in proximity to urban services, viewing, recreation cabin use, contact with others dominates	Road tours, camping with full service and facilities, viewing man's works, boating, cycling, organized games, gathering products, picnicking

Environmental Consequences

CHAPTER IV

ENVIRONMENTAL CONSEQUENCES

IN BRIEF

Part A describes the purposes of this chapter and defines the types of environmental effects analyzed. Parts B through M present the analysis of effects on each environmental element, and part N summarizes these effects for each alternative. Parts O through Q identify research needs, energy requirements, and conflicts with others. Parts R through T disclose unavoidable adverse effects, irreversible and irretrievable resource commitments, and relationships between short-term uses and long-term productivity.

A. INTRODUCTION

This chapter discloses the effects of each alternative on each environmental element described in chapter III, and forms the scientific basis for mitigation measures and comparisons of alternatives in chapter II.

If done without clear guidelines and reasonable restrictions some vegetation management activities can damage our environment. Many potential problems, however, can be anticipated, so ways to prevent them or minimize their severity can be required in advance. Management requirements and mitigation measures (chapter II, part E) are the "do's" and don't's" that workers and managers must use to protect our environment as they perform vegetation management.

To clearly display them to the reader, effects of vegetation management are discussed separately for each environmetal element. Effects can be direct, indirect, or cumulative.

Direct effects occur at the same time and place as the actions that cause them. Their causes are usually obvious.

Indirect effects occur at a later time or different place than the actions that cause them. Their causes may not be obvious and may stem from effects on other environmental elements.

Cumulative effects are the combined effects of these actions with those of other past, present, and future actions. Cumulative effects can be on-site (confined to the project area) or off-site (outside the project area). Effects on vegetation, cultural resources, or soil are chiefly on-site. Effects on water and air quality or wildlife and fish are commonly off-site.

More precise definitions of these three effects are in 40 CFR 1508.

1. Scope of Analysis

The Southern Region includes a variety of landscapes, plant communities, soil types, and climatic conditions. In order to account for some of these gross differences, we divided the Region into three parts for analysis of vegetation management activities. This environmental impact statement addresses only the Appalachians. See chapter III for a description of this area.

The area analyzed contains 5.2 million acres of national forests and has a complex variety of environmental conditions. We evaluate area-wide effects, and, where possible, sub-area effects. This approach is called "programmatic."

Within this broad area, site-specific vegetation management activities occur at hundreds of locations. Environmental effects from these projects vary with conditions on each project site. Many of these effects are predictable and are disclosed in this document. Other effects are unique to the site.

Recognizing this uniqueness, each project must be analyzed when proposed. The National Environmental Policy Act and Council on Environmental Quality Regulations describe a process called "tiering" to accomplish this evaluation. Tiering means the Forest Service will use and incorporate by reference any relevant information from this EIS and those done for Forest Land and Resource Management Plans when doing site-specific analyses for vegetation management projects.

Chapter II also describes environmental effects expected when different methods of vegetation management are used. Eight different ways (alternatives) to conduct the vegetation management program are evaluated. These approaches to doing work differ by:

1. Treating more or fewer acres either as a total or by individual methods.

2. Using or not using certain methods or tools.

3. Varying the intensity or frequency of application.

After reading about these effects and how they differ by alternative, the reader can refer back to chapter II, parts F, G, and H for comparison.

B. HUMAN HEALTH AND SAFETY

Discussion of human health and safety is presented in three parts:

1. Effects of herbicides. Herbicide effects on human health are evaluated in a risk assessment (appendix A) and are summarized in this section.

2. Effects of burning herbicidally-treated fuels. This section deals primarily with the analysis of risk to workers from herbicide residues present on fuels at the time of burning. Also included is an evaluation of risk from burning treated firewood.

3. Effects of other methods of vegetation management. This section deals with workers' risk of accident when using manual, mechanical, or biological methods or during prescribed burning.

Each section contains information about how the analyses were performed, including a summary of exposure routes and amount of exposure, associated inherent risk of each tool, and an assessment of the resultant risk of exposing people to that tool.

The evaluation of risk has two major facets -- risk assessment and risk management. In addition to following the formal risk assessment process, this EIS presents management requirements and mitigation measures to manage (reduce) risk (chapter II).

1. Effects of Herbicides

Source of Information

The human health risk assessment (appendix A) contains an analysis of the potential adverse effects to human health of 11 herbicides and 4 additives. The risk assessment was prepared by Labat-Anderson Inc. (LAI). Data from USDA Forest Service Agriculture Handbook #633 (Sassman and others 1984) and supplement (Sassman & Jacobs 1986) were updated based on more recent information provided to the Environmental Protection Agency (EPA) during the ongoing pesticide re-registration process. Background documents were prepared for light fuel oil (Weeks and others 1988a), imazapyr (Weeks and others 1988b), and mineral oil (Chin, Sczerzenie, and Haygood 1989; supplement to appendix A of this EIS). No data invalidated by EPA are used.

In addition to consultation with EPA, both LAI and the Vegetation Management Team exhaustively searched the scientific literature concerning health effects of herbicides. Inquiries were made of 21 library and toxicology data bases (DB) including: Medline, Toxline, Embase, Hazardous Substances DB, Registry of Toxic Effects of Chemical Substances DB, BIOSIS Previews, CAB (Commonwealth Agriculture Board) Abstracts DB, and Enviroline DB.

When available, only EPA validated data are used. Where unavailable (either required data not yet validated or data which is not required for registration) data from the open scientific literature were used. In two cases (inert ingredient data, and data concerning the dermal penetration rate of triclopyr), corporate proprietary data (inert ingredient data is confidential business data) or a pre-publication summary were used.

Four sections of the risk assessment (appendix A) apply to the analysis of human health effects:

- Section 2 describes methods currently used to apply herbicides in the Southern Region.
- Section 3 documents basic toxic properties of the chemicals (the hazard analysis).
- Section 4 documents probable exposures of workers and the public to these chemicals (the exposure analysis) by combining information from section 2 with estimates of hours worked and chemical use-rates.
- Section 5 combines predicted hazards and exposures to estimate the danger to workers and public (the risk assessment).

Hazard Identification

Human health effects are evaluated based on dose/time relationships. These relationships are expressed as:

> **Acute toxicity** -- the potential of a chemical to cause adverse health effects when administered in a single dose.

Subchronic toxicity -- the potential of a small dose of herbicide or additive administered daily for a relatively short period of time (generally about 30 days) to cause adverse health effects.

Chronic toxicity -- the potential of a small dose of herbicide or additive administered daily over a long period of time to cause adverse health effects.

Herbicides available to consumers are formulated products which contain technical product (active ingredient) and other chemicals or water (inert ingredients). Testing to determine toxic properties is done in the laboratory. Most tests are done with active ingredients, not formulated products (the product as sold, including active and inert ingredients).

Some evaluated health effects related to toxicity are:

Mortality -- death of test animals, which suggests the possibility of human death. Herbicide or additive toxicity is determined by the amount of chemical that kills one-half of the animals tested. EPA categories of acute toxicity are very slightly toxic (large amounts of chemical are needed to kill an animal); slightly toxic; moderately toxic; and severely toxic (small amounts of chemical are needed to kill an animal) (appendix A, table 3-1).

Organ effects -- abnormal growth (size or shape) or observable malfunction of organs. Generally the liver, kidney, and other major organs are closely monitored.

Doses which cause organ effects are stated as amount of herbicide or additive per unit of body weight per unit of time (generally milligrams of chemical per kilogram of body weight per day).

Exposure and Dose Response

To understand the subsequent discussion, a distinction must must be made -- exposure and dose are NOT the same thing. Exposure is the amount of substance which an organism contacts in the environment. Dose is the amount of that substance which is taken into an organism (by breathing, eating, penetrating the skin, or any other route). Thus, dose can equal exposure, but normally it is much smaller.

In section 4 of the risk assessment, exposure levels of workers and the public are computed. Section 5 discusses the probable doses resulting from projected exposure levels. These levels cover the herbicides and additives proposed for use. Exposure estimates consider ways in which exposure occurs, such as specific public or worker activity, rate of herbicide application, size of treatment area, method of application, and physical characteristics of the chemical (persistence or drift potential). Dose is computed considering probable routes into the body (dermal penetration, blood transport from lungs, etc.) at the projected exposure level.

Each exposure/dose projection is a series of possibilities running from no exposure/dose to some theoretical maximum for each factor. The number of combinations for seasonal timing, method of application, chemical, length of field day, number of field days per year per worker, etc. is incredibly large. To reduce the number of possible combinations, three specific exposure/dose scenarios are analyzed. Specific data are applied to each chemical and application method. These data approximate current and projected field activities (appendix A). The scenarios for which risk assessment is performed are:

> The **typical** situation estimates average dose resulting from exposure of workers and other people during routine operations.
>
> The **maximum** situation estimates the highest probable doses resulting from exposure of workers and other people when highest rates of chemical are applied by crew members who work a maximum number of hours per day for a maximum number of days per year. Maximum application rates used in Forest Service projects range from 1/20 (picloram) to 1/2 (imazapyr) labeled rates.
>
> An **accident** situation estimates dose resulting from exposure of workers and other people from direct exposure to herbicide resulting from a spill onto a worker or into a source of drinking water.

It is critical to remember that within each scenario ALL of the factors are relevant. The factors were mathematically modeled. Changing any factor changes the scenario and margin of safety projected for it. Risk is a function of dose -- but dose is critically dependent on several interrelated exposure factors and on toxicological properties of the chemical.

Potential movement of the herbicides and additives in the environment is estimated since this movement may also cause public exposure. Surface and subsurface movement (runoff and leaching) are estimated. Potential exposure due to drift of spray droplets is projected. Possible exposure as a result of either wildfire or deliberate burning (prescribed fire or firewood) is also predicted.

Exposure Information

Application rates and worker exposure times are based on actual projects and estimates of future use patterns in the Southern Region. Tables in the risk assessment show typical and maximum estimated hours per day and days per year a worker might be exposed, and typical and maximum amounts of chemical used per acre (tables 4-1 through 4-6, appendix A).

Estimates of public exposure are made for skin contact and consumption of food or water from forests treated with herbicides. Skin exposure is computed for visitors on-site and for off-site neighbors. People's dietary exposure is computed for consumption of contaminated water, fish, meat from wildlife or cattle, vegetables, and berries.

Separate exposure calculations are made for different herbicide application methods because each method has its own potential to expose workers to herbicides. For example, a mechanical sprayer delivering herbicide 15 feet from the operator has far less likelihood of getting herbicide on the worker than does a sprayer held in the worker's hand. Also, much less skin of a properly clothed worker (as in the typical operation) is exposed than with a worker not properly dressed (as for maximum exposure). The only route of exposure considered significant for workers in the typical operation is through the skin; however, in the maximum situation inhalation is also significant.

Accident projections use assumptions which reflect reasonably foreseeable adverse impacts:

- large amounts of skin are bare or directly exposed;
- a person is sprayed with the full per-acre rate of application on all exposed skin;
- a full backpack tank of spray solution covers the worker's skin and soaks the clothing which is worn for the entire workday;
- a full helicopter tank of herbicide (100 gallons diluted for application) is spilled into a reservoir;
- a 5-gallon container of undiluted herbicide is spilled into a small pond; and,
- additional exposure occurs in both water scenarios by drinking 1 liter of contaminated water.

Risk Description

Section 5 of the risk assessment converts exposure/dose data to project adverse health effects. The relationship between exposure and dose is influenced by the rate at which the chemical penetrates the skin (or is inhaled or ingested); how soon it is washed off; its potential to be broken down in the body; and how efficiently body systems eliminate it. Risk is directly related to dose and chemical toxicity.

EPA (1974, 1986b), the American Conference of Governmental Industrial Hygienists (1984), the National Agricultural Chemicals Association (1985), the National Research Council

(1983, 1986), and others have published standards for acceptable levels of chemicals in the environment, in ground water, or on foods. This EIS makes no value judgments (acceptable/unacceptable, safe/unsafe). It compares predicted risk with published standards to see if the herbicide or additive is more or less risky than the standard. Additional protective measures which reduce predicted risk to a level less than the standard are noted as management requirements or mitigation measures in chapter II.

Three measures of risk are:

> **Margin of safety (MOS)** -- compares the NOEL (no observed effect level) for laboratory animals and the dose estimated for different application operations. The NOEL is the dose of a chemical which can be administered to test animals causing no visible effects in subchronic testing. NOELS are evaluated for systemic (on the test animals) and reproductive (on their offspring) effects.
>
> According to the National Research Council (1986) acceptable levels of risk for a herbicide can be estimated. A safety factor of 10 based on test animal data, is used to predict human effects (between species variation). An additional factor of 10 is used to account for possible variations among humans (within species variation). If the NOEL divided by the dose results in a number greater than 100, a chemical is considered to pose an acceptable risk for the general population (excluding sensitive individuals). The higher this margin of safety, the lower the risk of adverse health effects. For example, if the NOEL is 100 mg/kg/day, then all doses of less than or equal to 1 mg/kg/day have margins of safety of 100 or greater (poses less risk than the standard), while all doses greater than 1 mg/kg/day have less than a 100-fold MOS (poses a greater risk than permitted under the standard).
>
> **Mutagenic potential** -- the possibility that the herbicide or additive will cause a change in the basic information-carrying structure (DNA) in the cell's nucleus. This is of special concern in reproduction where altered genetic information might be inherited by offspring.
>
> Evaluation of mutagenic potential is difficult. For some herbicides, no EPA-validated mutagenicity tests exist, or tests are insufficient to allow scientific conclusions. When no validated tests are available mutagenicity is assumed, and cancer potency values are

used to indicate the degree of mutagenicity. This represents the worst-case assumption.

Cancer potency -- an estimate of the possibility that a single exposure or a lifetime exposure to a herbicide or additive might cause cancer.

Data Gaps

Gaps exist in our knowledge. Incompleteness of data results from registration laws, age of data (tests performed in the past may be judged inadequate by current registration standards), and results from two or more tests which disagree. The Council on Environmental Quality regulations discuss the process for evaluating incomplete and unavailable information (40 CFR 1502.22(a) & (b)).

Data gaps which result in uncertainty about reasonably foreseeable significant adverse human health effects include the following:

1. Human toxicity data; moral restrictions and laws generally prohibit tests on human subjects. Animal tests are evaluated and mathematical models are used to project probable effects on humans, but human toxicity data are lacking.

2. Data on field worker exposure are available only for 2,4-D, 2,4-DP, dicamba, picloram, and triclopyr. Neither dermal penetration rates nor exposure estimates using current technology and mitigation are available for the other herbicides or additives evaluated.

3. Oncogenicity (the ability to cause either cancerous or non-cancerous tumors) data is unavailable for limonene, is incomplete for imazapyr, and has caused scientific disagreement for 2,4-D, 2,4-DP, fosamine, glyphosate, light fuel oil, picloram and triclopyr (table 3-6, appendix A). Mutagenicity data are generally incomplete or inconclusive (table 3-5 and 3-6, appendix A).

4. The effects of smoke inhalation in forest fire settings is fairly well documented. However, knowledge of risk from burning fuels that have been treated with herbicides is incomplete.

5. Experimental information is not available on the public's exposure to herbicides applied using current methods.

6. Field studies on residue levels in plants or animals in and around treatment areas are lacking for several herbicides. Comparison of data is very difficult because existing studies use different analytical methods.

7. Data concerning the biochemistry and activity of breakdown products of herbicides formed by metabolic or environmental action is incomplete.

8. Information about synergistic effects of herbicide combinations with other herbicides and with inert ingredients is unavailable.

9. Data relating to cumulative effects are unavailable.

There have been recent changes about how to evaluate incomplete or unavailable data. The Council on Environmental Quality issued regulations in November 1978 (40 CFR 1502.22) which required that a worst case analysis be performed to estimate risk of relevant missing information. In 1986, they modified this requirement to include analysis of "... reasonably foreseeable significant adverse effects to the human environment ..." (40 CFR 1502.22).

Recognizing that there are significant incomplete or unavailable data, we have prepared a risk assessment (appendix A) using the 1986 requirements. In the risk assessment, we evaluate maximum and accident scenarios to meet the intent of 40 CFR 1502.22.

40 CFR 1502.22(b) requires that when costs for filling data gaps are exorbitant or, when means to obtain the data are unknown, the agency's evaluation of impacts must be based on

theoretical approaches or research methods generally accepted in the scientific community. This analysis uses a risk assessment for missing data (appendix A). This approach which "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council, 1983).

Although some of the data gaps are identified, an adequate data base was found to permit risk assessment of each of the 15 herbicides and additives within NEPA guidelines. Throughout the analyses, conservative estimates (greatest risk to humans) were used to approximate missing or incomplete data. The risk assessment analyzes reasonably foreseeable maximum use and accident scenarios in which extreme exposure to herbicide occurs.

Each test needed to provide data which are currently unavailable or incomplete costs from tens of thousands (mutagenicity, worker exposure) to over a million dollars (chronic toxicity, oncogenicity). If all tests were performed, direct costs would be tens of millions of dollars. In addition, by delaying vegetation management indefinitely to complete testing, the public would suffer increased hazard from wildfire, and production of goods and services would be reduced (see analysis of the effects of Alternative A). The Forest Service considers that delay-caused fire hazard, delay-caused deterioration of services, and costs to fill these data gaps are too great to justify postponing issuance of this environmental impact statement.

Even if we ignore the magnitude of this potential investment, the inherent difficulty of analysis of human health effects remains. Studies on animals are modeled to approximate human health effects, but, especially for chronic effects, the relevance of 2 to 4-year studies on animals when compared with a 60 or more year life span for a human has been seriously questioned. However, the relevance of the concept of chronic exposure when applied to relatively non-persistent herbicides is questionable.

Acute Toxicity

Acute toxicity is the potential to cause death when the dose is by mouth (acute oral toxicity) or by skin (acute dermal toxicity) or other route. Estimates of acute human toxicity are based on acute toxicity values (single-dose mortality) determined for test animals in laboratory experiments using pure (technical grade) herbicides, generally administered one herbicide at a time.

The more toxic the product, the less is required to cause death. A dose of more than a pint (16 fluid ounce) of a very slightly toxic herbicide is required to cause the death of an average adult (150 pound) human. Similarly, between 1 fluid ounce and a pint of slightly toxic herbicide would kill an adult; between a teaspoonful (1/6 fluid ounce) and one fluid ounce of a moderately toxic herbicide is lethal; but, less than a teaspoonful of severely toxic herbicide or additive is required to cause death.

Acute oral toxicities of the chemicals are (appendix A, table 3-2):

- Very slightly toxic--Diesel oil, fosamine, imazapyr, kerosene, limonene, mineral oil (classes 4 and 5), picloram and sulfometuron methyl.
- Slightly toxic--Dicamba, glyphosate, hexazinone, tebuthiuron, triclopyr, and 2,4-DP.
- Moderately toxic--2,4-D.
- Severely toxic--None.

Acute dermal toxicities are reported to be (appendix A, table 3-3):

- Very slightly toxic--Dicamba and mineral oil (classe 4 and 5).
- Slightly toxic--2,4-D, 2,4-DP, diesel oil, glyphosate, hexazinone, imazapyr, kerosene (tentative), limonene (tentative), picloram, sulfometuron methyl, and triclopyr.
- Moderately toxic--Fosamine and tebuthiuron.
- Severely toxic--None.

Irritation

It is also necessary to know if a herbicide is an irritant does it cause skin or eye problems? The risk assessment shows the amount of each chemical causing primary dermal o primary eye irritation. EPA (1974) categories are:

- IV- No irritation to the eyes; mild or slight skin irritation at 72 hours.
- III- No corneal opacity; moderate skin irritation a 72 hours.
- II- Corneal opacity reversible within 7 days; sever skin irritation at 72 hours.
- I- irreversible corneal opacity at 7 days; corrosi to the skin.

Primary dermal irritations by the chemicals are (appendix A, table 3-3):

- Category IV--2,4-DP (Weedone formulation), dicamba, fosamine, glyphosate, imazapyr, kerosene, limonene, mineral oil (classes 4 and 5), picloram, tebuthiuron and triclopyr.
- Category III--2,4-D, hexazinone and sulfometuron methyl.
- Category II--Diesel oil.
- Category I--None.

Primary eye irritations by the chemicals are (appendix A, table 3-3):

- Category IV--2,4-DP, diesel oil, kerosene, mineral oil (classes 4 and 5), and tebuthiuron.
- Category III--Dicamba, glyphosate, imazapyr, picloram and sulfometuron methyl
- Category II--Hexazinone and triclopyr.
- Category I--2,4-D.
- No data--Fosamine and limonene.

No Observed Effect Levels

Systemic NOELs range from a low of 1 mg/kg for 2,4-D to a high of 500 mg/kg for imazapyr; only 2,4-D, sulfometuron methyl, and triclopyr are less than 5 mg/kg (appendix A, table 3-2). Reproductive NOELs are reported between 2.5 mg/kg (dicamba and triclopyr) and 751 mg/kg (light fuel oils) (appendix A, table 3-2). Systemic NOEL of mineral oil is 2 ml/kg (highest dose tested, supplement 1, appendix A). Class 5 mineral oil is approved by the Food and Drug Administration for use as a direct multi-purpose food additive (21 CFR, Part 172.878) and for use in animal feed (21 CFR, Part 573.680) subject to provisions in the subparts.

Effects of Inert Ingredients

An inert ingredient is not necessarily chemically unreactive; it is simply not the active ingredient in the formulation. EPA's Office of Pesticide Programs (EPA 1987) has identified about 1,200 inert ingredients currently used in pesticides, and they have categorized these chemicals based on their ability to cause chronic human health effects as follows:

- List 1--Inerts of toxicological concern: approximately 50 chemicals shown to be carcinogens, developmental toxicants, neurotoxins, or potential ecological hazards which merit highest priority for regulatory action.

- List 2--Potentially toxic inerts: about 50 chemicals with toxicity data suggesting, but not confirming, possible chronic health effects or having chemical structures similar to chemicals on list 1. They are high priority for testing.

- List 3--Inerts of unknown toxicity: approximately 800 chemicals were placed here "... if there was no basis for listing it on any of the other three lists." Priority for further testing is low.

- List 4--Inerts of minimal concern: about 300 chemicals generally regarded as innocuous. Priority for testing is low.

Inert ingredient information is presented in the risk assessment (appendix A, table 3-8). None of the chemicals evaluated is on List 1 and only one chemical (kerosene) is on List 2. One additive is unclassified and the remaining inert substances are on list 3 or 4. In all cases, formulated products (the products as purchased which include both active and inert ingredients) have lower risk of acute toxic effects than the active ingredient alone (appendix A). Class 4 or 5 mineral oil, if used as an inert ingredient to replace kerosene, is on list 4.

Current Forest Service policy is to permit use of formulations containing List 3 or List 4 inerts. Formulations containing List 2 chemicals are used only when no formulation with only List 3 or List 4 inert ingredients are available meet project objectives, and only after an evaluation of the inert ingredient shows that health risks are acceptable. Formulations containing List 1 inerts are not used.

Exposure Levels

Tables 4-25 through 4-40 in the risk assessment display projected public, worker and accident exposure levels. Important reference points are discussed below.

Berry pickers exposed to 0.14 mg/kg/day fosamine in the maximum exposure scenario represent the highest projected level of public exposure. Levels less than 0.00001 mg/kg/day are projected for public dermal exposure to drift of 2,4-DP and picloram, and for public dietary exposure to imazapyr (via fish), limonene (fish), picloram (fish), and sulfometuron methyl (water, fish, or meat) when these chemicals are applied at typical rates. Many worker exposure levels in the maximum scenario are greater than 1 mg/kg/day (a very high level of exposure). Maximum scenario exposures range from 1.5 to 100 or more times as great as typical exposure levels. For workers in normal settings, both typical and maximum scenarios show the mixer/loader and the backpack (broadcast foliar) applicator have the greatest exposure.

Accidental spills involving workers cause the greatest individual exposure. The range is from 1020 mg/kg/day for diesel oil to 0.29 mg/kg/day for picloram. No other accident scenario for any other chemical shows greater than 0.5 mg/kg/day exposure.

Typical Public Scenario

Tables IV-1 through IV-5 display human margin of safety data. These tables summarize data presented in tables 5-8 through 5-23 of appendix A (risk assessment).

Comparison of estimated MOS's for typical public exposures (table IV-1) indicates that no member of the public, including sensitive individuals, should be affected by herbicides or additives proposed for use in Region 8. This generalization applies to systemic and reproductive effects.

Maximum Public Scenario

For the maximum public exposure scenario (table IV-2) only berry pickers who eat about 1 lb unwashed, contaminated berries are at risk. Systemic MOS's are greater than 100 for all chemicals used in this scenario except for 2,4-D (amine and ester), triclopyr (amine and ester), and 2,4-DP. For the reproductive MOS's, only berry pickers/eaters are at risk and only in areas where fruiting plants have been treated with 2,4-D ester, 2,4-DP, dicamba, and triclopyr (amine and ester) which have MOS's of less than 100. Berries sprayed with these products should not be eaten.

No public exposure for either the typical or maximum aerial application scenario has a MOS less than the 100-fold criterion other than in the case of eating foraged berries as already discussed.

Typical Worker Scenario

2,4-D and tebuthiuron are of concern for workers when applying herbicides with backpack sprayer (table IV-3). Each shows at least one systemic or reproductive MOS of less than 100.

Mixer/loaders and applicator/mixer/loaders are at risk of systemic toxic effects when either the ester or amine of 2,4-D is used. Also at risk are workers doing broadcast foliar treatments, and those applying the amine formulation as a cut-surface treatment. The reproductive MOS is less than 100 for ester and amine 2,4-D formulations broadcast onto leaves using backpack sprayers.

Tebuthiuron MOS's of less than 100 for reproductive and systemic effects indicate a risk of adverse effects for unprotected workes who repeatedly use it in broadcast foliar treatments with a backpack sprayer.

Without additional mitigation, 2,4-D and tebuthiuron have MOS's of less than 100 for applicators in several scenarios. Mitigtion to improve MOS's can include reducing the acreage sprayd by an individual applicator, wearing

Table IV-3.--Public risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS

	2,4-D														TRICLOPYR	
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER
Dermal																
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	LO	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Berry pickers	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Based on a systemic NOEL of:																
(mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5

REPRODUCTIVE MOS

	2,4-D														TRICLOPYR	
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER
Dermal																
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Foraged berries	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Based on reproductive NOEL of:																
(mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); ■ = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

NOTE: Chemical names are abbreviated in tables IV-HH1 through IV-HH5 as follows: DICAM = dicamba, DIES = diesel oil, FOSAM = fosamine, GLYPH = glyphosate, HEXAZ = hexazinone, IMAZA = imazapyr, KEROS = kerosene, LIMON = limonene, PICLO = picloram, SULFO = sulfometuron methyl, and TEBUT = tebuthuron.

Table IV-3.—Public risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Public																
Dermal																
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	LO	LO	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	LO	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	LO	LO
Vegetable	LO	LO	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Berry pickers	VH	VH	VH	LO	LO	LO	LO	LO	I	LO	I	LO	LO	LO	HI	HI
Based on a systemic NOEL of: (mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5

REPRODUCTIVE MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXA	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Public																
Dermal																
Drift	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Onsite	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dietary																
Water	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Meat	LO	LO	LO	LO	I	I	I	I	I	I	I	I	I	I	LO	LO
Vegetable	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Foraged berries	LO	HI	HI	HI	I	I	LO	LO	I	I	I	I	I	LO	HI	HI
Based on reproductive NOEL of: (mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

Table IV-3.--Worker risk in the typical scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D														TRICLOPYR	
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER
Aerial																
Pilot	LO	LO	I	N	I	LO	I	I	I	I	I	I	I	I	LO	I
Mixer/loader	[illegible]	[illegible]	I	N	LO	LO	I	LO	I	LO	I	I	I	LO	LO	LO
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground																
Applicator	LO	LO	I	I	LO	I	I	I	I	I	I	I	I	I	LO	LO
Mixer/loader	[illegible]	[illegible]	I	I	LO	I	I	LO	I	LO	I	I	I	I	LO	LO
Appl/Mix/Load	[illegible]	[illegible]	I	I	LO	I	I	LO	I	LO	I	I	I	I	LO	LO
Manual ground																
Backpack spray	[illegible]	[illegible]	I	N	N	LO	LO	LO	I	LO	I	I	LO	[illegible]	LO	LO
Basal stem	N	LO	I	N	LO	N	N	N	N	I	I	N	N	N	N	LO
Soil spot	N	N	N	N	N	N	N	LO	N	N	N	N	N	I	N	N
Cut surface	[illegible]	N	N	I	N	N	LO	N	I	N	N	I	N	N	LO	N
Based on a systemic NOEL of: (mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5

REPRODUCTIVE MOS	2,4-D														TRICLOPYR	
	AMINE	ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	AMINE	ESTER
Aerial																
Pilot	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	I
Mixer/loader	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground																
Applicator	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO
Mixer/loader	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO
Appl/Mix/Load	LO	LO	I	LO	I	I	I	I	I	I	I	I	I	I	LO	LO
Manual ground																
Backpack spray	[illegible]	[illegible]	I	N	N	I	LO	I	I	I	I	I	I	[illegible]	LO	LO
Basal stem	N	LO	I	N	I	N	N	N	N	I	I	N	N	N	N	LO
Soil spot	N	N	N	N	N	N	N	I	N	N	N	N	N	I	N	N
Cut surface	LO	N	N	LO	N	N	LO	N	I	N	N	I	N	N	LO	N
Based on reproductive NOEL of: (mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); ▇ = High risk (MOS is between 1 [illegible]; ▇ [illegible] (MOS is less than 1), N - Not Applicable

Table IV-4.—Worker risk in the maximum scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Aerial																
Pilot	HI	HI	I	N	LO	LO	LO	LO	I	LO	I	I	LO	LO	LO	HI
Mixer/loader	HI	HI	I	N	LO	HI	LO	LO	I	HI	I	I	LO	HI	HI	HI
Observer	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground																
Applicator	VH	VH	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI
Mixer/loader	HI	HI	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI
Appl/Mix/Load	VH	VH	I	LO	HI	HI	HI	HI	I	HI	LO	I	LO	HI	HI	HI
Manual ground																
Backpack spray	VH	VH	LO	N	N	HI	HI	HI	I	HI	LO	I	HI	HI	HI	HI
Basal stem	N	VH	I	N	VH	N	N	N	N	LO	I	N	N	N	N	LO
Soil spot	N	N	N	N	N	N	N	LO	N	N	N	N	N	I	N	N
Cut surface	VH	N	N	LO	N	N	LO	N	I	N	N	I	N	N	LO	N
Based on a systemic NOEL of: (mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5

REPRODUCTIVE MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Aerial																
Pilot	LO	HI	I	N	I	I	LO	LO	I	I	I	I	I	LO	LO	HI
Mixer/loader	HI	HI	I	N	I	I	HI	LO	I	I	I	I	I	LO	HI	HI
Observer	I	I	I	N	I	I	I	I	I	I	I	I	I	I	I	I
Mechanical ground																
Applicator	VH	VH	I	HI	I	I	HI	HI	I	LO	LO	I	I	LO	HI	HI
Mixer/loader	HI	HI	I	HI	I	I	HI	HI	I	LO	LO	I	I	LO	HI	HI
Appl/Mix/Load	VH	VH	I	HI	I	I	HI	HI	LO	LO	LO	I	I	HI	HI	HI
Manual ground																
Backpack spray	VH	VH	LO	N	N	LO	HI	HI	LO	LO	LO	I	LO	HI	HI	HI
Basal stem	N	LO	I	N	I	N	N	N	N	I	I	N	N	N	N	LO
Soil spot	N	N	N	N	N	N	N	I	N	N	N	N	N	I	N	N
Cut surface	VH	N	N	VH	N	N	HI	N	I	N	N	I	N	N	LO	N
Based on reproductive NOEL of: (mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5

KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable

Table IV-6.—Human risk in the accident scenario; systemic and reproductive MOS values are used to compare risk levels

SYSTEMIC MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Spill onto worker	VH	VH	HI	VH	VH	VH	VH	VH	HI	VH	VH	HI	VH	N	VH	VH
Accidental spray	HI	HI	I	LO	HI	HI	LO	HI	I	HI	I	I	LO	HI	HI	HI
Spill into water																
Ground	HI	HI	LO	I	LO	LO	I	LO	I	I	I	1	HI	LO	HI	HI
Air	LO	LO	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO
Based on a systemic NOEL of: (mg./kg.)	1	1	5	25	7.38	25	31	10	500	28	227	7	2.5	12.5	2.5	2.5

REPRODUCTIVE MOS	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAM	DIESE	FOSAM	GLYPH	HEXAZ	IMAZA	KEROS	LIMON	PICLO	SULFO	TEBUT	TRICLOPYR AMINE	TRICLOPYR ESTER
Spill onto worker	VH	VH	HI	VH	VH	HI	VH	VH	HI	HI	VH	LO	VH	N	VH	VH
Accidental spray	HI	HI	I	HI	I	LO	HI	LO	I	I	I	I	I	HI	HI	HI
Spill into water																
Ground	LO	LO	LO	LO	I	I	LO	I	I	I	I	I	LO	LO	HI	HI
Air	I	I	I	N	I	I	I	I	I	I	I	I	I	I	LO	LO
Based on reproductive NOEL of: (mg./kg.)	5	5	6.25	2.5	751	500	10	50	300	751	227	50	25	20	2.5	2.5

Ground spill is assumed to be 5 gal into a pond; air spill is assumed to be 100 gal into a reservoir. KEY: I = Insignificant risk (MOS exceeds 1000); LO = Low risk (MOS is between 100 and 1000); HI = High risk (MOS is between 1 and 100); VH = Very high risk (MOS is less than 1); N = Not applicable full body waterproof coveralls, or reducing the number of days per year an applicator sprays these two herbicides. Reducing exposure improves the MOS.

Maximum Worker Scenario

For workers applying herbicides in the maximum exposure scenario (table IV-4), several chemicals are of concern. Systemic MOS's for 2,4-D (amine and ester), diesel oil, fosamine, glyphosate, hexazinone, kerosene, tebuthiuron, and triclopyr (amine and ester) all have at least one worker exposure which failed to exceed an MOS of 100. Reproductive MOS's also fail to exceed 100 for some 2,4-D, dicamba, glyphosate, hexazinone, tebuthiuron, and triclopyr application methods. Remember that maximum scenarios are based on assumptions that, acting together, greatly magnify the estimate of risk (appendix A).

Accident Scenario

In the accident scenario several exposures are of concern (table IV-5). For systemic effects, all spills directly onto workers who did not immediately wash had either high (MOS between 1 and 100) or very high (MOS less than 1) risk levels. When a person (worker or member of the public) is accidentally sprayed during either aerial or ground spray projects, 2,4-D, diesel, fosamine, hexazinone, kerosene, tebuthiuron, and triclopyr have MOS's of less than 100. MOS's for a ground spill (5 gallons into a pond) of 2,4-D (amine and ester), sulfomturon methyl, and triclopyr (amine and ester) are less than 100 (greater risk than the standard). All MOS's projected for aerial spills are greater than 100 (less risk than the standard).

For reproductive effects, all spills onto workers have MOS's below 100 except for picloram. Granular tebuthiuron was not evaluated. For spills into water, only triclopyr (amine or ester) has a MOS of less than 100.

Herbicide Oncogenicity

An analysis of maximum cancer risk was performed for 2,4-DP which has positive laboratory oncogenicity studies; for light fuel oils (diesel and kerosene) which contain small amounts of materials known or suspected of causing cancer; and for 2,4-D (amine and ester formulations), glyphosate and picloram for which there is scientific uncertainty about their ability to cause cancer. Cancer risk was not assessed for mineral oils (Class 4, mildly hydrotreated; Class 5, white oils and perolatums) which show no evidence of carcinogenicity. Inadequate data exist to evaluate severely hydrotreated Class 4 mineral oils. Evidence was found indicating carcinogenicity of less refined mineral oils (supplement 1 to appendix A).

Data on fosamine, triclopyr, and limonene are unavailable, and imazapyr's data are incomplete. There is no evidence to show that any of the other chemicals could cause cancer; all have studies showing no effect (appendix A).

Computation of lifetime cancer risk to the public from the seven chemicals evaluated (table IV-6 and appendix A, tabl 5-26) showed no risk greater than 2 in 10,000,000. Compare this with the values presented in table 5-28 of the risk assessment. The worst risk estimated for any of these chemicals is only 1/35th the risk of getting cancer from exposure to a single x-ray.

However, lifetime cancer risk to workers (table IV-6 and appendix A, table 5-26) is greater than 1 in 1,000,000 for workers in all categories of application of 2,4-D and for backpack sprayer application of 2,4-DP. All other evaluations for cancer potency showed risks to the worker o less than 1 in 1,000,000 (fewer than 1 in 1,000,000 workers are expected to get cancer).

Mutagenicity

Glyphosate, imazapyr, class 5 mineral oil, and sulfometuron methyl have tested negative for mutagenicity. Hexazinone, dicamba, picloram, tebuthiuron, and triclopyr are nonmutagenic in the majority of assays and pose slight to negligible mutagenic risk. Fosamine presents a very slight risk of causing mutagenic effects. No mutagenicity testing has been updated by EPA for limonene. The Food and Drug Administration, however, reports that it is "generally regarded safe" as a food additive (appendix A, table 3-6).

Both 2,4-D and 2,4-DP have shown mixed mutagenicity test results. According to Sassman and others (1984) they do no pose significant risk of human gene mutation . However, because of the mixed data on mutagenicity, both are considered to pose a mutagenic risk equivalent to their cancer potency. EPA has requested more testing.

Diesel oil and kerosene also present mixed results. Both contain small amounts of the carcinogenic compounds benzene and benzo(a)pyrene. Weeks and others (1988a) report that these compounds have the same low-order risk of causing heritable mutation as is reported for their cancer potency.

Bioaccumulation

Bioaccumulation is the process whereby a chemical is concentrated in tissue at a level greater than in the environment (Ottoboni 1984). To bioaccumulate a chemical must be absorbed into the body at a rate greater than it is eliminated (either through chemical breakdown or via excretion). Temporary storage in cells is not bioaccumulation. Bioaccumulation is a dynamic equilibrium process; it is not instantaneous but requires that the body be allowed time to come to an equilibrium and later to improve on that equilibrium. Bioaccumulation can occur onl when the body fails to eliminate a substance.

Table 3-4 in the risk assessment shows elimination rates reported for nine chemicals: 2,4-D, 2,4-DP, dicamba, fosamine, glyphosate, hexazinone, imazapyr, picloram, and

Table IV-6.--Lifetime cancer risk

	2,4-D						
	AMINE	ESTER	2,4-DP	DIESE	GLYPH	KEROS	PICLO
Public							
Dermal							
Drift	L	L	L	L	L	L	L
Onsite	L	L	L	L	L	L	L
Dietary							
Water	L	L	L	L	L	L	L
Fish	L	L	L	L	L	L	L
Meat	L	L	L	L	L	L	L
Vegetable	L	L	L	L	L	L	L
Berry pickers	L	L	L	L	L	L	L
Workers							
Aerial							
Pilot	■	L	L	L	L	L	L
Mixer/loader	■	■	L	L	L	L	L
Observer	L	■	L	L	L	L	L
Mechanical ground							
Applicator	■	■	L	L	L	L	L
Mixer/loader	■	■	L	L	L	L	L
Appl/Mix/Load	■	■	L	L	L	L	L
Manual ground							
Backpack	■	■	■	NA	L	L	L
Basal stem	NA	■	L	L	NA	L	NA
Soil spot	NA	NA	NA	NA	NA	NA	NA
Cut surface	■	NA	NA	NA	L	NA	L

KEY: ■ = Risk greater than 1 in a million; L = Risk less than 1 in a million; NA = Not Applicable

triclopyr. Elimination rates for diesel oil, kerosene, limonene, mineral oil, sulfometuron methyl, and tebuthiuron are not available at present. Elimination varied from 100 percent (2,4-D [rat/5 days], dicamba [rat/48 hours], fosamine [rat/72 hours], and hexazinone [rat/72 hours] to a low of only 74 percent (2,4-DP 74-82 percent/rat/4 days). Some herbicide had not been eliminated at termination of the study for: glyphosate (8 percent/rabbit/5 days), imazapyr (13 percent/rat/24 hours), picloram (10 percent/dog/48 hours and 4 percent/unspecfied test animal/24 hours), and triclopyr (9-17 percent/rat/unspecified time). The most rapid elimination reported is for hexazinone (93 percent/rat/2 hours) while the slowest is shown above for 2,4-DP.

It is unclear from the studies if these amounts of not-eliminated material represent the lowest expected level at which equilibrium is established or if further elimination continued after the termination of the studies. Classic concepts of chemical half-life in the organism and bioaccumulation as permanent storage conflict and the controversy is unresolved. Bioaccumulation, in the popular sense of continuous addition of new chemicals to an overwhelming burden, does not appear to occur with these herbicides. The bodies of test animals responded to exposure by eliminating the herbicides, not by permanently adding them to a previously accumulated stockpile of other chemicals. The limited number of exposure studies performed on field workers support this conclusion when applied to humans (appendix A).

Synergism

Synergistic effects of chemicals are effects which occur from exposure to two or more chemicals either simultaneously or within a relatively short period. To be considered synergistic an effect must be greater than the sum of the effects of each agent alone.

The herbicide mixtures evaluated for the Southern Region's vegetation management program have not shown synergistic effects in humans who have used them in other applications.

Toxic effects of possible herbicide combinations other than those commercial mixtures registered by EPA have not been studied. Time and money normally limit toxicity testing to the highest priority -- evaluation of toxic effects of each chemical alone. Based on the limited amount of data available about effects of herbicide combinations, it is very unlikely that toxicologically significant synergistic effects could occur from exposure to two or more of the chemicals evaluated (appendix A).

There are several reasons which make the probability of the occurrence of synergism involving the evaluated herbicides extremely small. Herbicide residue in plants and soil does not persist from application to application. This results from the relatively short persistence and infrequent usage of herbicides on each site. These herbicides herbicides are rapidly excreted from the body. Exposure to two or more chemicals at the same time is likely only in cases where those chemicals are combined in a single spray mixture. Workers having frequent contact with different herbicides are exposed to some risk of synergism. Public exposure to forestry herbicides is minimal and extremely infrequent.

The Environmental Protection Agency's guidelines for the health risk assessment of chemical mixtures (EPA 1986a) reflect the problem of missing and unavailable data with respect to synergism. While not recommending any specific process for risk assessment, they do consistently explain the use of additive models which do not recognize possible effects greater than those caused by the known effects of the chemicals in the mixture.

2. Effects of Prescribed Fire

Brown-and-Burn

Brown-and-burn combines the use of herbicides and fire. Herbicide is applied, vegetation is allowed to dry for 30 to 100 or more days, and then prescribed fire is used to reduce the above-ground fuel load and open the site for reforestation.

Because of concerns about the effect burning herbicide-treated vegetation might have on the health of the public and workers, two brown-and-burn scenarios are evaluated in the risk assessment (appendix A). This analysis has two purposes; to determine a sufficient interval to ensure that worker and public risk is low, and to evaluate the potential health risk resulting from wildfire occurring immediately after herbicide application.

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Fuel load, smoke density, and amount of fuel consumed are based on Southern Region data for representative fuel types. Published degradation rates are used to estimate the amount of herbicide remaining intact at the time of fire. Maximum exposures are calculated for a wildfire occurring on the day of treatment.

Several assumptions were necessary due to missing or incomplete data. In all cases, assumptions were made in a conservative manner (maximum reasonable risk was chosen over lesser risk) causing estimates of risk to be high. This increases the margin of safety for workers and the public.

Threshold limit values (TLV) published by the American Conference of Governmental Industrial Hygienists (1984) are used as an indicator of the lowest acceptable level of risk from herbicide residue in smoke. TLV values indicate an acceptable level of workers' daily exposure (8 hours per day) to airborne chemicals over their careers.

Even in the wildfire scenario (wildfire occurs the same day as application) the worst exposure projected is 46 times less than the TLV. All herbicide/application-method brown-and-burn combinations evaluated after 30 days (minimum vegetation curing time period) are estimated to have significantly less risk than the TLVs allow. Seventy-four times less exposure than the TLV is the closest any typical herbicide/method combination came to the TLV. Based on this comparison there is negligible risk of negative health effects from herbicide used in brown-and-burn operations.

Bush and others (1987) measured residues released from burning herbicide-treated wood (in wood stoves or fireplaces). Herbicides evaluated were 2,4-D, 2,4-DP, dicamba, picloram, and triclopyr. Evaluation was made 4, 8, and 12 months after treatment. Residues under rapid combustion were generally much less than under slow combustion. They found that more than 95 percent of the tested herbicides were broken down by the heat of a well developed (800-1,000°C) fire. These concentrations are much less than the maximum exposure concentrations estimated for these herbicides in brown-and-burn operations (appendix A, table 5-24). Thus no significant potential exists for negative human health effects from the burning (in a hot fire) of firewood treated with these herbicides.

Bush and others (1987) also report that during slow combustion, relatively stable compounds such as 2,4-D, 2,4-DP, and dicamba were released in significant amounts. However, the levels reported were less than 1/1,000 of those judged to pose negligible risk when ingested on a daily basis.

Recent information by McMahon (1989) further suggests that brown-and-burn poses little additional risk to workers than prescribed burning untreated fuels. Worker monitoring using air samplers worn during fire fighting activities detected no significant parent herbicide residue in 12 fires. Label rates of hexazinone, imazapyr, picloram, or triclopyr had been used to pretreat fuels on all sites. Detection level of the samplers was 1 mg/m^3 and workers on the fires were exposed to 350 to 4,000 mg/m3 of particulate matter for between 1 and 5 hours.

3. Effects of Other Methods (General)

People are concerned about worker health and safety for all methods used in vegetation management.

Sources of Information

Although extensive accident reporting systems exist (U.S. Department of Health and Human Services, Office of Workman's Compensation, and insurance companies), forestry-related activities cannot be isolated from data recorded in these systems. Additionally, national summaries of accidents (U.S. Department of Labor, Bureau of Labor Statistics and others) report only numbers of accidents. Therefore, data are taken directly from Southern Region accident reports. Four years of accident reports are analyzed. A total of 814 accidents involving field personnel requiring the care of a doctor were reported during fiscal years 1984 through 1987. Of the 814 field accidents regionwide, 171 are directly related to vegetation management. The 76 Appalachian Mountain forest accidents directly related to vegetation management are the basis for subsequent discussion.

Accident Frequency

Accidents have been reported from use of manual and prescribed burning methods. No accidents have been reported from mechanical or biological methods. The only reported herbicide related accident was a worker who slipped while carrying a backpack unit and twisted his ankle.

There were no vegetation management-related fatalities during the 4-year period for which detailed accident records are available. Fatality records are maintained for a longer period of time, and during the period 1976 - 1985, two tree felling deaths and two fire-related deaths were related to vegetation management.

No data exist to determine occurrence rates of other health problems. Such things as loss of hearing due to loud tools, cancers resulting from inhaling fumes from gasoline engines or gasoline contacting skin, and secondary infection of a wound from vegetation management are not reported in a way which allows analysis. All could occur, but frequency of occurrence is unknown.

Frequency of accidents by body part affected are presented in table IV-7. In table IV-8, frequency of accidents as a function of the activity being performed is displayed. Figure IV-1 shows the number of accidents expected during a 25-year career. Overall, traumatic injuries to the back, hand and skin predominate.

Table IV-7.--Body part affected: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Appalachian Mountain forests; Region 8, FY'84-FY'87

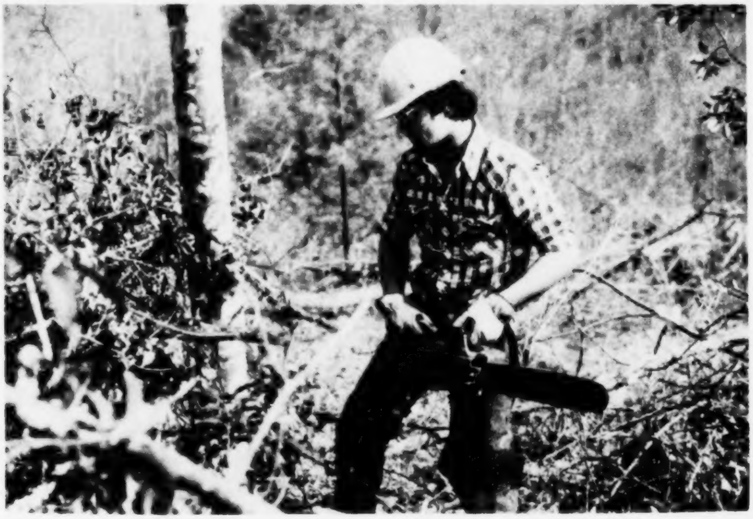
	Site Prep	Pres Burn	Range	Wildlife	Road Maintenance	Trails & Recreation Maintenance
Head, Neck, Ear, Nose	0.009	0.033	0.140		0.005	0.019
Eye	0.005	0.067		0.006	0.005	0.005
Skin	0.003	0.033		0.012	0.011	0.014
Arm						
Wrist, Hand Finger	0.010				0.011	0.009
Back, Chest, Abdomen	0.003	0.033			0.005	0.009
Legs	0.007				0.016	0.019
Ankle, Foot, Toes	0.006					0.005
Other	0.001					0.005
Total by Activity	0.049	0.163	0.140	0.018	0.054	0.084

Blank cells = no accidents reported during the four years being investigated.

Table IV-8.--Cause of injury: Average number of accidents per man year (40% field work) worked in several vegetation management activities in Appalachian Mountain forests; Region 8, FY'84-FY'87

	Site Prep	Pres Burn	Range	Wildlife	Road Maintenance	Trails & Recreation Maintenance
Insects	0.004	0.033		0.006	0.005	0.009
Fire						
Hand tools	0.012			0.006	0.005	0.009
Power tools Chain saw	0.009				0.005	0.005
Power tools Other	0.002				0.011	
Struck by Vegetation	0.005	0.065		0.006	0.011	0.009
Slipping	0.006	0.033			0.011	0.024
Lifting	0.006					
Dust & Debris	0.001	0.033				0.005
Poisonous plants	0.002				0.005	0.009
Other			0.140			0.014
Total by Activity	0.049	0.163	0.140	0.018	0.054	0.084

Blank cells = no accidents reported during the four years being investigated.



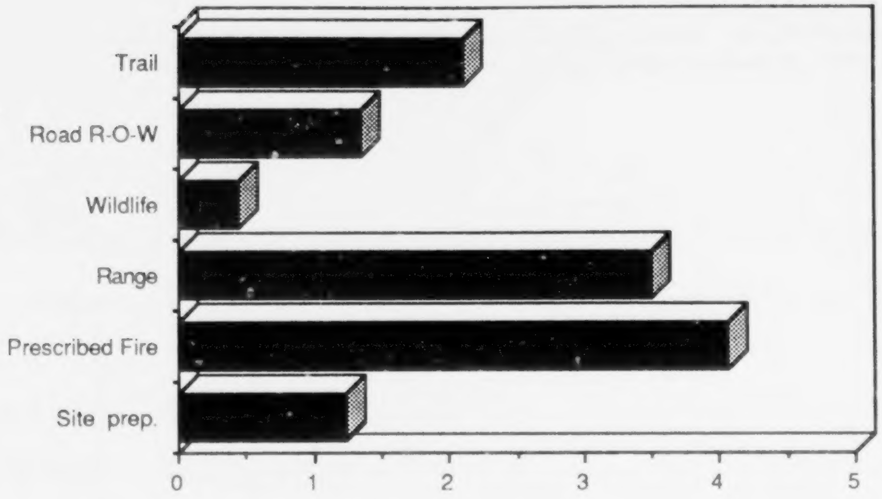


Figure IV-1.--Expected number of accidents per person during a 25-year (40% field work) career performing a single vegetation management activity on an Appalachian Mountain forest.

Based on tables IV-7 and IV-8 and figure IV-1, vegetation management activities rank as follows (most to least risky):

1. Prescribed burning
2. Range management
3. Trail maintenance
4. Road maintenance
5. Site preparation work
6. Wildlife habitat management

High risks include: a 3.5 in 10 chance of accidental head injury (to workers involved full time in range management activities, this is an accident every three years); a 1.7 in 10 chance of eye injury to workers doing prescribed burning; an approximately 1 in 10 chance of skin, head, or back problems to full-time workers doing prescribed burning; a 5 in 100 chance of head or leg injuries for full-time workers doing trail and recreation maintenance (an average of 1 accident per 25 years of full time field work); and, a 4 in 100 risk of leg injury for workers doing road right-of-way maintenance.

Severity Rating

Severity rating is based on reported costs: low ($1 - $100), moderate ($100 - $500), and high (over $500). Severity of accidents related to site preparation is notable; 5 in 39 are in the severe category; 14 in 39 are moderately severe; and only slightly more than half are low severity accidents. Overall the ratios of low:moderate:severe accidents are similar between activities.

Table 5-28 of appendix A displays the risk of cancer or death resulting from several routine activities. Vegetation management activities contain more risk of accidental injury than these routine activities, though the consequences are normally less severe than death.

Figure IV-2 shows the average worker's risk of having an accident in a 25-year career. After correcting for the relative amounts of time spent in each activity, activities are rated (most to least risk): site preparation, recreation and trails maintenance, road right-of-way maintenance, wildlife habitat management, and range habitat maintenance (figure IV-2).

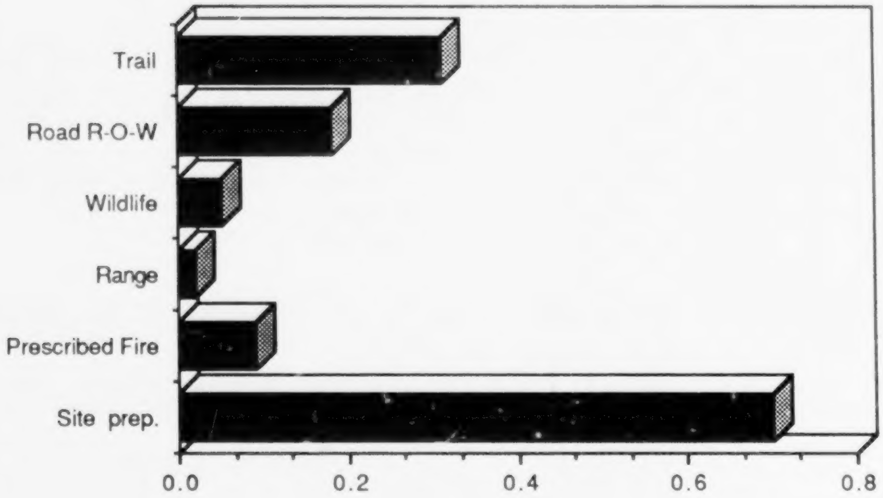


Figure IV-2.--Average number of accidents suffered by a worker working for 25 years (40% field work) in a vegetation management job with activity proportional to the average work program for Appalachian Mountain forests.

C. VEGETATION

1. Effects of Prescribed Fire

a. Forest

The following introduction on the historic influence of fire, unless otherwise cited, is summarized from Van Lear and Waldrop, appendix E.

Historic Influence

Throughout history fire has been a major influence in the development of Southern Appalachian mountain vegetation communities. Prior to man's arrival, lightning-caused fires shaped the development of vegetation in the mountains. As compared with the southeastern pine region, the frequency of these lightning-caused fires was probably much less.

Approximately 10,000 years ago fire frequency significantly increased in this area with the arrival of Indians. The Indians used fire to promote hunting success, reduce wildfires, clear understory vegetation, improve wildlife habitat, and facilitate food gathering. From the 1700's settlers influenced the area through burning for forage production for grazing animals, land clearing, and slash burning. Extensive areas were annually burned and grazed. Loftis (1978) refers to an extensive survey by Ayers and Ashe in 1905 that states that 80 percent of the Southern Appalachian forest land had been repeatedly burned as indicated by fire scars. This survey was conducted watershed by watershed over 6.5 million acres in the southern Appalachian Mountains (Lorimer 1985).

Changes began during the 1920's when extensive burning became prohibited. However, a resurgence of the use of fire occurred to reduce hazardous fuels after the disastrous wildfire seasons of the 1930's and 1950's. Prescribed fire techniques were developed which involved the carefully planned use of fire under specific site and weather conditions to achieve specific project objectives for activities such as seedbed preparation and wildlife habitat improvement.

Fire today is not as widespread in the Southern Appalachian mountains as it has been in the past. Many of today's pine and hardwood stands were established 60 to 100 years ago when fire and grazing were dominant practices. However, more research is needed on the use of prescribed fire for regeneration of these hardwood stands. Some researchers believe that the exclusion of disturbances, especially fire, from mature oak stands on better sites has altered the ecology of those stands thereby reducing the production of advance oak regeneration.

Injury and Mortality

Prescribed fire can injure or kill vegetation. Whether or not a plant is injured or killed depends upon plant characteristics, fire type and behavior, topography, wind speed, temperature, length of exposure, and season.

Fire kills or damages plant leaves, needles, buds, stems, bark, branches, or roots. Extent of injury depends on species, age, diameter, height, and protective adaptations. Young, succulent, and actively growing vegetation is especially vulnerable (Hare 1961; Loomis 1973). For this reason, losses are generally greatest for seedlings or sprouts of any species.

Hardwood species are generally much less resistant to fire damage than are pine species (Wade 1983). In a literature review by Fennell and Hutnik (1970), that emphasized hardwood forests of eastern North America, several studies determined that within a size class yellow poplar is more resistant to fire damage than oaks. Among oak species, chestnut oak is the most resistant followed by white oak, red oak, and black oak with scarlet oak the least resistant to fire damage. Hickory, red maple, and sassafras were found to be less resistant to fire damage than oaks.

Little mortality occurs from low-intensity fires once hardwoods are greater than 3 inches in diameter at breast height (d.b.h.) (Chen, Hodgkins, and Watson 1975; Goebel, Brender, and Cooper 1967; Van Lear and Waldrop 1988). Most southern yellow pines are rarely killed once greater than 8 to 12 feet tall or more than 2 inches in groundline diameter (Cain 1985a; Komarek 1974; Wade 1986).

Protective adaptations such as protected buds, thick bark, ability to resprout, and natural pruning of lower branches decrease the risk of plant injury or death (Gill 1981; Van Lear 1985). When little damage is done to the buds of pines they can survive even severe needle loss (Wade and Johansen 1986a, 1986b).

Tree bark provides protection from fire temperatures. Species which have thicker bark are much less susceptible to fire damage (Hodgkins 1958; Langdon 1971; Wade 1986). In addition, natural pruning of lower branches of many pine species prevents low to moderate intensity prescribed fire from reaching tree crowns. Hare (1965) determined that tree species differ significantly in their resistance to damage by fire due to differences in bark insulation effectiveness and thickness. Of the species tested, when comparing trees of equal bark thickness, longleaf pine was almost twice as resistant to damage as sweetgum, black cherry, and American holly.

Thin barked pine species such as Virginia pine and white pine are highly susceptible to fire damage (Frothingham 1914; Slocum and Miller 1953; Van Lear and Waldrop, appendix

E). Other conifers such as red spruce and Fraser fir are also easily damaged or killed by fire due to their thin bark, shallow root systems, and low crowns (Korstian 1937; Van Lear and Waldrop, appendix E; Westveld 1953). Among hardwoods, beech, birch, and maple are thin barked species that are susceptible to basal stem injury and root damage by fire (McCarthy and Sims 1935).

Species resistance increases with tree diameter, due to increased bark thickness and crown height with age, and is also dependent on the intensity and duration of fire (McCarthy and Sims 1935). Trotta (1980) studied the effects of low intensity prescribed fire on 40 to 60 year old white pine-mixed hardwood forests in New Hampshire. He found that in general all tree species were more resistant to fire damage as their bark thickness and stem diameter increased. Of the mature tree species, white pine and red oak were more resistant than red maple to fire damage. Greatest injury occurred to trees less than 4 inches d.b.h. Understory woody species were topkilled; height reduction was temporary, lasting 3 to 4 growing seasons, as most species (except white pine seedlings and saplings) resprouted. White pines were more resistant to damage from low intensity fire once they reached 3 to 4 inches d.b.h. and had rougher and thicker bark.

Ability to resprout when the above-ground portion of the plant is killed is another important adaptation. Although pines are normally more resistant than hardwoods to damage from fire, if pines are top-killed (when the entire above-ground portion of the plant is killed) they do not readily resprout. Exceptions to this are shortleaf and pitch pine which will readily sprout when topkilled by fire (Van Lear and Waldrop, appendix E).

Prescribed fire increases basal sprouting of hardwood species (Augspurger and others 1986; Danielovich and others 1987; Sanders, 1985). This ability decreases with increasing age and size of the hardwoods. Some hardwood species that have proven to be vigorous sprouters when topkilled by fire include oaks, black cherry, red maple, dogwood, blackgum, sourwood, and basswood (Fennell and Hutnik 1970; Henderson 1986; Teuke and Van Lear 1982).

Fire type and behavior also determine whether plants are injured or killed. In the mountains, intensity and rate of spread of surface fires depends upon amount and type of fuel present, fuel moisture, slope, aspect, wind speed and direction, season, temperature, and humidity. Slope, aspect, wind speed, and direction are especially critical variables when trying to predict fire behavior. Fires spread significantly faster when moving upslope than they do across level terrain (Rothermel 1983).

Three types of fire occur. Crown fires consume the tops of trees, are very intense, and kill most vegetation. Surface fires consume woody shrubs, vines, and herbaceous vegetation. Ground fires burn below the surface and kill the roots of plants.

Surface fires are the fires manipulated for prescribed burning. Intense surface fire in areas with large amounts of available, continuous fuel create a high risk of injury or death to vegetation. According to Langdon (1981), backing fires with flame lengths of 3 feet or less develop fireline intensities to 60 Btu/ft/sec, while flanking and strip-head fires develop fireline intensities from 60 to 160 Btu/ft/sec (flame heights of 3 to 4.5 feet). Prescribed fires with flame lengths greater than 5 feet (190 Btu/ft/sec) may not be controllable. He also noted that at an intensity of 600 Btu/ft/sec (flame heights of 8.5 feet) , surface fires are not generally controllable and may move into the crown fire category.

Effectiveness of upslope and downslope fires in controlling competing vegetation and reducing fuel levels was examined by York and Buckner (1983) for a Cumberland Plateau site. Their study found that upslope and downslope fires were equally effective for understory hardwood topkill (92 percent) and fuel reduction (51 percent); however, upslope fires had greater crop tree mortality, significantly higher rates of spread (212 ft/hr versus 66 ft/hr), and were more difficult to control.

Season

Temperature, length of exposure, and season significantly affect plant survival. According to Hare (1961) plant tissues are instantly killed at 140°F. Johnson (1974) examined northern red oak seedling mortality after an early growing season burn in Wisconsin and found that mortality rates were related to temperatures at seedling root collars. Mortality rates were 71 percent when temperatures reached 220°F, 64 percent with temperatures between 140 to 219°F, and 19 percent when root collar temperatures were less than 140°F. Also, plants can be killed at somewhat lower temperatures when the duration of exposure is increased. The temperature the plant is exposed to depends on distance from the flames and fire intensity (Hare 1961; Wade and Johansen 1986a).

Growing-season fires injure or kill more vegetation than dormant season fires. In one study on an upland site in northwestern Alabama by Hodgkins (1958), burns conducted during August (growing season) killed 97 percent of 1-inch d.b.h. pines, and 60 percent of 2- and 3-inch d.b.h. pines. Burns conducted during January (dormant season) killed 41 percent of 1-inch d.b.h. pines, and no 2- or 3-inch d.b.h. pines.

York and Buckner (1983) in conducting prescribed fires during May, August, and October in a 26-year old loblolly pine stand found that the early growing season burn (May) created the most intense fire and caused the most pine crop tree mortality (22 percent). However, it was the most effective in competition control (98 percent hardwood topkill) and fuel reduction (66 percent). Burns conducted during August and October were less effective due to difficulties with higher humidities and fuel moisture levels.

Olson and Weyrick (1987) stated that in southern New Hampshire prescribed fires have been found effective in controlling mesic species such as red maple, black birch, red oak, balsam fir, and hemlock in white pine stands. They found that summer burns may be more effective than spring burns in controlling woody understory species, but depending on the weather conditions and openness of a stand, summer burns may also cause extensive damage to the white pine overstory.

Hodgkins (1958) found that August burns top-killed 62 percent of 1-inch d.b.h. hardwoods, 52 percent of 2-inch d.b.h. hardwoods, and 38 percent of 3-inch d.b.h. hardwoods; while in January 46 percent of 1-inch d.b.h. hardwoods, 5 percent of 2-inch d.b.h. hardwoods, and no 3-inch d.b.h. hardwoods were top-killed. Within 2-1/2 years dense new hardwood growth replaced the top-killed individuals on all burn plots. On a Southern Appalachian mountain site Danielovich and others (1987) determined that intense late growing season site preparation burns (August), of areas containing standing residual hardwoods, topkilled 64 percent of all residual stems. The smaller diameter stems were more readily topkilled; more than 70 percent of the stems 3 to 4 inches in stump diameter and more than 80 percent of the stems 1 to 2 inches in stump diameter were effectively topkilled.

Lotti, Klawitter, and Legrande (1960) determined that dormant season fires did not kill rootstocks of hardwoods; top-killing occurred but the hardwoods resprouted. They found that growing season fires not only top-killed stems but also killed the roots of many hardwoods. However, Langdon (1981) found that growing season burns for 10 consecutive years were required to kill all rootstocks. Annual winter burns did little to kill rootstocks even after 30 consecutive years of burning. Growing season burns were found by Ferguson (1961) to be the most effective in topkilling stems and that 90 percent of the stems resprouted. Early and late growing season burns completely killed 10 percent of oak stems, while dormant season burns completely killed less than 2 percent of the oaks in the study area. Brender and Cooper (1968) also determined that greater mortality to understory hardwoods occurs with growing season fires. Chen, Hodgkins, and Watson (1975) found no significant difference in understory hardwood mortality, however, between growing- and dormant-season burns. They determined that growing-season burns reduced vigor of resprouting hardwoods.

Some of these responses are due to seasonal temperature differences. Dormant season air temperatures are generally low and more fire heat is needed to reach the lethal 140°F mark than during the growing season when ambient air temperature is quite high (Fennell and Hutnik 1970; Wade 1983; Wade and Johansen 1986b).

Mortality cannot be easily determined immediately following a fire. Some external indicators of fire injury to plants include color changes in needles or leaves, bark scorch, and possibly pitch flow (Hare 1961). Loomis (1973) indicated that accurate damage estimates in hardwoods that include both delayed mortality and obvious wound development can be made after 1 or 2 growing seasons. Injuries may only set back or weaken plants. Accurate losses from severe fire may not become apparent for several years.

Prescribed fire can cause less immediate effects than obvious plant injury or mortality. These latent effects include changes in susceptibility to insects and disease, reproduction, nutrient content, and growth response.

Plant Susceptibility

Fire can increase or decrease plant susceptibility to damage from insects and disease. Wounds such as fire scars increase susceptibility by weakening plants and providing entry points for insects and disease. Additional mortality can occur from stem breakage at wounds (Fennell and Hutnik 1970).

Fennell and Hutnik's (1970) review of a study by Gustafson in eastern Kentucky outlines decay losses from fire as being dependent upon species growth rates, bark thickness, resistance to decay, and area of cambium killed. Hardwood species that were most severely damaged by fire through decay losses were dogwoods, sourwoods, maple, and beech; followed by hickories, blackgum, elm, ash, basswood, and butternut. Least damaged were oaks, yellow poplar, and black walnut. In species that have low resistance to decay, stems may be significantly affected above the area of obvious wounding. Berry (1982) states that in some of the more susceptible species such as sugar maple, decay may be found 5 feet above a fire scar, in yellow birch it may extend to 14 feet, while in ash, decay can spread 1.5 inches/year starting 2 or 3 years after being wounded. In more resistant species like chestnut oak, white oak, and black oak, loss of stem quality will be minimal where wounds are less than 6 inches wide, but oaks with fire wounds greater than two-thirds the circumference of the tree 1 foot above ground level should be removed. Nelson, Sims, and Abell (1933) correlated wound size with amounts of bark discoloration. They diagramed bark burn, char, and scorch areas on yellow poplars and oaks from a mountainous site in Virginia that received a very severe early growing season fire. One growing season later they removed the bark to diagram the wounds. They found yellow poplars more resistant to wounding than oaks; and that even when high amounts of bark were discolored, larger diameter poplars developed small wounds. In contrast, scarlet oaks were least resistant and developed severe wounds with only small amounts of bark discoloration.

On a Southern Appalachian mountain mixed pine-hardwood site, Sanders, Van Lear, and Guynn (1987) found that low intensity dormant season backing fires, with average flame lengths of 6 inches or less, caused cambium damage to 20 percent of hardwood trees 3 to 5.5 inches in diameter, 5 percent of hardwoods 5.6 to 10.5 inches in diameter, and 4 percent of hardwoods 10.6 to 15.5 inches in diameter. Hardwoods greater than 15.5 inches in diameter had no cambium damage. They concluded that low intensity prescribed fires would have little to no adverse effect on stem quality of medium to large diameter (5.6 to greater than 15 inch) mature hardwoods.

Fire decreases disease susceptibility by reducing or controlling brownspot needle blight of longleaf pine grass stage seedlings (Maple 1977), annosus root rot of loblolly pine (Froelich, Hodges, and Sackett 1978), and fusiform rust of loblolly pine (Hare 1961; Lotan and others 1981). Prescribed fires that kill the lower branches of young white pine may provide disease protection from white pine blister rust and some fungi-caused needle diseases (Olson and Weyrick 1987). The quality of oak sprouts may be improved through the use of prescribed fire by producing sprouts that originate lower on stumps; this may provide more decay resistant sprouts (Augspurger and others 1986; Roth and Sleeth 1939; Van Lear and Waldrop, appendix E).

Reproductive Success

Success of reproductive functions such as germination, flowering, fruiting, and seed production is affected by fire. Cushwa, Martin, and Miller (1968) observed that during simulated fire conditions moist heat significantly increased the germination of some species of legume seed. Fire may cause the seed in the soil to break dormancy, but can reduce germination and destroy seeds when lethal plant temperatures are reached.

Garren (1943) in reviewing some of the early work of Chapman reported a great increase in germination of longleaf pine seed where prescribed burns were implemented just before seedfall occurred. Low intensity spring backing fires have been found to stimulate white pine seed germination (Olson and Weyrick 1987). Prescribed fire enhances the regeneration of yellow poplar by releasing seed stored on the forest floor (Shearin, Bruner, and Goebel 1972). Fire cherry is another species whose seed remains viable on the forest floor for many years. Its seed is highly resistant to heat damage, following a fire it germinates and grows rapidly and will dominate the site for several years (Fennell and Hutnik 1970).

Seeds of other species are not as resistant to heat damage. Among oak species, red oak and chestnut oak acorns are most resistant to heat damage, while white oak, scarlet oak, and black oak are least resistant (Fennell and Hutnik 1970). In general, germination success is directly enhanced by the reduction of competition for light and nutrients and by seedbed preparation that exposes some mineral soil. Fire also initiates the opening of cones of serotinous pines (Langdon 1981), such as table mountain pine and possibly Virginia pine (Van Lear and Waldrop, appendix E). When overstory species are severely wounded and receive high amounts of crown damage following a fire, seed production may be restricted for several years (Fennell and Hutnik 1970).

Early growing season burns in an Eaton and White (1960) study increased the number of sprouts and buds of lowbush blueberries. Blueberry production is stimulated and maintained by early growing season burns that are implemented prior to spring growth (Kautz 1986). Kautz states that blueberry production is highest the second year following fire, by five years production drops to low levels. A two or three year burning cycle was recommended to maintain high production levels. Stransky and Halls (1979a) found that dormant season burns produced an increase in the fruit yield of dogwood but in general produced a mixed response of fruit yields of woody plants.

Nutrient Content

Nutrient content of some forage species is increased by prescribed burning. Campbell and others (1954) found both protein and phosphorus are increased until May by late dormant season burns.

Growth Response

Prescribed fires can change the environment in which plants grow. They remove litter from the ground surface, and temporarily reduce other woody or herbaceous species that compete for growing space, moisture, nutrients, and light required for optimal success in germination and establishment.

Growth responses from burning have been positive and negative. Pearson (1983) found that spring or fall prescribed burns had no effect on the growth of 40 to 60 year old eastern white pine stands in New Hampshire. Early growing season burns have been found to improve height growth of longleaf pine seedlings (Grelen 1975, 1983; Maple 1977). However, in young longleaf pine saplings, Boyer (1985, 1987) found that biennial dormant or growing season burns of varying fire intensity produced from backfires, flanking fires, and strip-head fires, all reduced young longleaf pine height, diameter, basal area, and volume.

Depending upon fuel load and weather variables, low to moderate intensity fire can be expected to result in low to moderate amounts of crown scorch. Lilieholm and Hu (1987) working with loblolly pine also found that light amounts of scorch may increase growth. Waldrop and Van Lear (1984) found that moderate crown scorch did not affect the growth of unthinned young loblolly pine trees of dominant or codominant crown classes. Complete crown scorch caused 20 percent mortality of codominant and 30 percent mortality of intermediate crown classes. High amounts of scorch can be expected to produce decreases in diameter and height growth of loblolly pine (Cain 1985b).

After a winter backing fire in a 4 year old loblolly pine stand, Waldrop and Lloyd (1988) found no loss of diameter growth, but a significant reduction in height growth occurred. During the first year after burning, height growth was reduced for each of the first three growth flushes, even when crown scorch was light. An additional loss of growth occurred during the first flush when crown scorch was heavy.

Jemison (1944) studied effects of basal wounding on the growth rate of some Southern Appalachian hardwood species and found that even severe basal wounding by fire had no significant effect on the diameter growth rate of 8 to 10 inch white oaks and black oaks, and 8 to 18 inch yellow poplars 7 to 14 years after a fire. Scarlet oak did have a reduced growth rate 14 years after wounding. Jemison also found that wounds caused only temporary obstruction to the flow of food and water in these trees, movement around the wounds quickly developed.

Community structure can be altered by temporary changes in canopy position and species composition. More long-term effects from prescribed fire occur as successional changes resulting from the interaction of species composition with fire intensity, frequency, and season over time.

Canopy Position

Lay (1967) noted that fire effects on understory vegetation are dependent on characteristics of understory prior to treatment. When fire is used in an understory of low-growing woody species, the amount of browse is reduced temporarily, but the quality of browse is improved. When fire is used in higher understory, canopy position is lowered as tops are killed, but resprouting is rapid, and ultimately more browse becomes available. Chen, Hodgkins, and Watson (1975) determined that winter and summer burns reduced canopy height of woody species by more than 6 feet, and summer burns additionally reduced vigor of resprouting hardwoods. A prescribed burn study on the Cumberland Plateau in an oak-pine site showed a decrease in the height of the understory hardwoods but an increase in the total number of hardwood stems which hindered shortleaf pine regeneration (Fennell and Hutnik 1970).

Species Composition

Species composition changes occur with increased fire intensity and frequency. Season of burn is also an important variable. More intense fire causes greater shifts in species composition by reducing small woody species and increasing quantities and types of herbaceous vegetation through the preparation of seedbeds more favorable to herbaceous species (Van Lear and Johnson 1983). On a southern Appalachian Mountain site, Sanders (1985) found that herbaceous species under hardwood and pine types increased after one low intensity burn but the increase was not significant. Some herbaceous species that increased included galax, pipsissewa, braken fern, aster, and switchcane. As intensity increases, legumes and other forbs and grasses are especially favored (Cushwa, Brender, and Cooper 1966; Cushwa and Redd 1966; Czuhai and Cushwa 1968).

In southern New England, Niering, Goodwin, and Taylor (1970) assessed impacts of low intensity prescribed fire on species composition in mixed oak-cherry, mixed oak-birch, and mixed oak-white pine-pitch pine stands. Overall, most small trees and shrubs were topkilled; rootstocks were killed only on small size classes of species more sensitive to fire damage. In the oak-birch stand, one year after treatment, 100 percent of the 1 to 2-inch size class birch were rootkilled; while 50 percent of the white oak, black oak, and hickory in the same size classes were only topkilled. In oak-birch and oak-cherry stands, smaller woody understory stems were reduced, but no damage was observed to larger trees (up to 12 inches d.b.h.). In the oak-pine stand, white pine saplings less than 1 inch d.b.h. and all seedlings were rootkilled, while pitch pine seedlings and saplings were only topkilled and later resprouted. They found 18 ground cover species in the prescribed burn plot, while the no treatment control plots contained seven species. The burns especially favored spotted wintergreen.

Single burns that occur once per stand rotation, especially of low to moderate intensity, do not significantly change species composition. One winter (dormant season) or summer (growing season) burn initially reduces hardwood vegetation, but it recovers to previous levels in 5 to 7 years (Langdon 1971). Wade and Wilhite (1981) noted woody species recovery to nearly preburn levels by 6 years. Martin and others (1979), Lorimer (1985), Huntley and McGee (1983), and Van Lear and Waldrop (appendix E) also concluded that burning initially reduces woody species coverage, but woody species composition is not significantly changed.

Phillips and Abercrombie (1987a, 1987b) used early growing season site preparation burns on medium quality southern Appalachian Mountain sites to establish mixed pine-hardwood stands. After the regeneration cut, standing residual stems are felled after the initial growth period in the spring. During July these areas are broadcast burned with an intense fire over a moist fuel bed. Results indicate good growth and survival of planted pines along with good growth and form of hardwoods. Burning temporarily knocks back hardwood sprouts allowing pine seedlings to become established.

In south-central New York State, Swan (1970) measured tree species response to wildfires and found that northern hardwood stands were more susceptible to fire damage than oak stands. Northern hardwood stands had 35 percent of their trees categorized as dead or dying, while oak stands had 16 percent. Oak saplings were also more fire resistant, 87 percent resprouted following fire, while only 43 percent of the northern hardwood saplings resprouted. The area studied had a history of periodic wildfire which produced a fire resistant community that favored oaks and reduced the amount of northern hardwood seedlings and saplings.

In West Virginia, Carvell and Maxey (1969) examined changes in species composition three growing seasons following wildfire in dense cove hardwood sapling stands. Approximately 44 percent of the cove hardwood species (primarily yellow-poplar, basswood, northern red oak, cucumber tree, and white oak) were dominant trees prior to the fire; while 23 percent were dominant after the fire. Oak and hickories increased (54 percent dominant) due to their resistance to fire damage.

Lorimer (1985) speculated that unsuccessful oak regeneration on better sites may be due to the lack of periodic fire during the past few decades, where historically these oak dominated areas had frequent fires which selected against oak competitors and favored the fire-resistant oaks.

Due to understory competition from other species, oak regeneration is more difficult on moist, fertile, cove sites than on drier sites. Some research indicates that environmental conditions on cove sites have been sufficiently altered by the exclusion of fire so as to prohibit oak regeneration (especially that of northern red oak). Further research is needed to determine whether prescribed fire has a role in promoting advance oak regeneration on these better quality cove sites. Research needs to find out whether or not there is a combination of season, frequency, and number of burns that would stimulate oak reproduction (Van Lear and Waldrop, appendix E).

Teuke and Van Lear (1982) studied the effects of dormant season backing fires on understory species composition and effects on oak regeneration in mixed pine-hardwood stands in the mountains of north Georgia and northwestern South Carolina. These burns only slightly improved the competitive position of oak regeneration through improved form, density, and decrease of oak competitors. The size reduction of oak regeneration proved to be a significant disadvantage. On better quality cove sites, Loftis (1988) found that one low intensity prescribed burn had no positive effects on oak regeneration. McGee (1979, 1980a) found no significant effects of one prescribed fire on species composition and dominance in 5 to 6 year old hardwood stands in northwest Alabama. Young stands were topkilled but quickly resprouted, with most species retaining their same relative competitive positions as before the prescribed fire. McGee concluded that one prescribed fire doesn't favor the development of oak regeneration but that possibly additional burns or burns in stands less than 5 or 6 years old would benefit the competitive position of oaks. Nyland Abrahamson, and Adams (1983) recommend two successive early growing season site preparation burns implemented two to three years apart to promote oak regeneration and to sufficiently suppress competition. In West Virginia, Wendel and Smith (1986) also found that one burn doesn't enhance oak reproduction and suggested multiple low intensity burns may be necessary to improve the competitive position of oak regeneration under an overstory. Van Lear and Johnson (1983) suggest initiating frequent low intensity burns for oak regeneration 10 to 15 years prior to harvest.

Harlow and Bielling (1961) recommend burning cycles for specific objectives; a 3-year cycle to produce high amounts of forbs and legumes, 4 to 6 years for best understory hardwood growth and mast production, and annual burns for the greatest variety and number of plant species. Johnson and Landers (1978) recommended a 3-year burning cycle for the production of fruiting plant species for wildlife.

Fire Frequency

Frequency and season of burn combine to create significant impact on species composition. Frequent prescribed burns reduce woody species and increase herbaceous species (Lewis and Harshbarger 1976). Frequent burns result in less vigorous sprouts and fewer sprouts as more rootstocks are killed with each successive fire (Chen, Hodgkins, and Watson 1975; Grano 1970a; Johnson 1982; Trousdell 1979). However, Keetch (1944) found that southern Appalachian hardwoods' ability to resprout was not reduced by three successive moderate to high intensity early growing burns and no losses in growth rate or vigor occurred.

In Tennessee Thor and Nichols (1974) examined the effects of annual and periodic (every 5 years) winter burns on hardwood understory species and reproduction. They found that compared with the no treatment area (8070 stems/ac), annual (13,051 stems/ac) and periodic (12,540 stems/ac) prescribed burn areas had significantly more hardwood understory stems. Southern red oak had the greatest increase in stems per acre on both burns, followed by post oak and scarlet oak. On the no treatment area, blackgum had the greatest number of stems per acre.

In New Hampshire, Trotta (1980) concluded that fires more frequent than every 10 years would eliminate white pine and hemlock understories due to their low fire resistance and lack of reproduction potential at that age and size.

Lotti, Klawitter, and Legrande (1960) determined that woody species control was minimal with annual winter burns because rootstocks of most species survived, and once annual burns were discontinued woody species regained dominance. Van Lear and Johnson (1983) also noted that annual winter burns do not reduce the number of hardwood sprouts but only affect the size of sprouts, whereas annual summer burns effectively eliminate small woody stems. Frequent prescribed burns can effectively prevent seedling establishment of woody species. Dormant season burns are not effective in killing the roots of woody species, but frequent growing season burns are, and also result in greater changes in species composition.

Successional Patterns

Prescribed fire can result in vegetation dominated by herbaceous species. Intensity, frequency, and season are some of the most important factors determining what species dominate. Fennell and Hutnik (1970), in reviewing work by Ahlgren, cite 13 factors that can affect vegetation succession following fires: pre-burn condition, season, seed supply, fire intensity, ash concentration, subsequent mineral nutrition, soil moisture, rainfall, humidity, soil temperature, air temperature, animal populations, and plant competition. Long-term use of fire at frequent intervals, especially during the growing season, restricts the development of woody species and promotes herbaceous species.

The fire succession pattern described by Hare (1961) is dominated first by forbs, then perennial grasses, and ultimately perennial woody species. Vegetation resulting from a given fire depends on initial stand composition, fire intensity, available seed sources, and prefire and postfire weather variables (Fennell and Hutnik 1970).

The successional pattern for southern pine forests is a gradual replacement of pines by invading hardwoods. Understory burns in southern pine forests retards this successional pattern (Pyne 1984).

Lewis and Harshbarger (1976) reported the effects of 20 years of prescribed burning in South Carolina flatwoods. Their study looked at seasonal and frequency impacts on woody and herbaceous vegetation from annual, biennial, and periodic dormant and growing season burns. They concluded that after 20 years of burning the understory had been significantly altered. Annual summer (growing season) burns eliminated almost all shrubs, had the highest number of herbaceous species (29), and grasses became the dominant herbaceous species. Annual winter (dormant season) burns resulted in numerous low-growing shrubs, had the next highest number of herbaceous species (26). Biennial summer (growing season) burns were similar to annual summer burns in that most shrubs were reduced, it had the third highest number of herbaceous species (24). Both types of periodic burns occurred when 25 percent of hardwood stems reached 2 inches in diameter. Periodic summer (growing season) burns created site conditions dominated by low-growing shrubs, had an intermediate number of herbaceous species (22). Periodic winter (dormant season) burns also left sites dominated by low-growing shrubs, had the second lowest number of herbaceous species (18). The control area was not burned, and was dominated by low-growing shrubs. It also had the lowest number of different herbaceous species (11).

Results of this study after 30 years, summarized by Waldrop and others (1987), determined that season and frequency combine to produce significant differences in understory species composition and size class development. On periodic dormant and growing season burns, two size classes developed consisting of hardwood understory species greater than 6 inches d.b.h., and those less than 2 inches d.b.h. The larger size class represented species not topkilled at the initiation of the study. The smaller size class represented sprouts of species that were topkilled by each fire. No intermediate classes developed because burns were frequent enough to prevent growth into size classes between 2 and 6 inches. Annual winter (dormant-season) and biennial summer (growing season) burns were similar in that both had many understory woody species less than 3 feet tall which are topkilled sprouts. They differ in that more grasses occur on biennial summer burns. Annual summer burns still produced the greatest reduction in woody understory vegetation. Frequent burning killed woody root systems and promoted development of an herbaceous understory. Annual growing season burns kill root systems by gradually depleting root carbohydrate reserves. Oak root systems were the most resistant thereby giving them an advantage over other species when burning is frequent. Although further research is needed to document results for frequent Southern Appalachian understory burns, it is expected that the effects may be similar (Van Lear and Waldrop, appendix E).

b. Appalachian Mountain Balds

Fire is the most frequent method used in grassy and heath balds management (Lindsay 1977). Prescribed fire effectively prevents woody species encroachment and maintains grass species but is relatively ineffective where woody species are already established. Woody species such as fire cherry, rhododendron, mountain laurel, blueberries, and blackberries are effectively topkilled by fire but most will resprout (Lindsay and Bratton 1979b). Blackberries (Rubus spp.) apparently are stimulated to spread by prescribed fire if already present (Haskell 1986; Murdock 1986), as are mountain oat and other grasses (Hare 1961; Haskell 1986; Lea 1986; Komarek no date; Murdock 1986). Very little is known about the relationship of fire to many Appalachian Mountain grassland flowers, but some experience has shown that fire may stimulate many of them (Komarek no date).

Results of Forest Service work indicates that prescribed fire is 75 percent effective in controlling woody species encroachment and increasing herbaceous species coverage on the edges of balds; while on other areas of balds it can prevent further encroachment but not set back established woody species (Lindsay 1977).

Reviewing balds maintenance burns on National Forests in North Carolina, Lindsay (1977) related that fall prescribed burns were more effective than spring burns due to more favorable weather and fuel conditions; however, their disadvantages were lack of sufficient ground cover and increased erosion potential through the winter. Thomas (1986) stated that spring burns are favored due to rapid revegetation following treatment which reduces erosion and nutrient losses; and when late spring burns are used (during active growth) they are more effective in killing woody stems. Haskell (1986) also concluded that woody species control could only be achieved during the active growing season. Dormant season burns provide mixed results; they promote grass and forb seed germination, and stimulate established grasses, but they also increase black locust (Robinia pseudo-acacia) and blackberry sprouting.

Successful spring burns on balds within the Mount Rogers NRA have reduced dense blackberry patches, improved palatability and nutritional value of livestock forage, and overall have been 70% effective in controlling woody species while increasing herbaceous species (Thomas 1986). He recommended an annual or 2-year burn cycle on areas with significant woody vegetation to reduce the woody component and thereafter a 3-year cycle.

Lilly (1980) studied woody and herbaceous species response to single and repeated growing season (spring) burns on mowed and unmowed sites on the Big Meadows areas of Shenandoah National Park. Herbaceous species increased growth and woody species decreased growth on unmowed areas receiving a single growing season burn and on mowed areas receiving repeated growing season burns. On mowed and single burn areas, woody species initially decreased but rapidly recovered and remained competitive with herbaceous species. Lilly also concluded that annual growing season burns or a combination of fall mowing plus growing season burning promotes blackberries and reduces black locust.

Barden (1978) concluded that, based on the average frequency (1 fire per 10 years per 25,000 acres) and low intensity of most lightning fires, natural fire frequency is inadequate to maintain grassy balds. He estimated that lightning fires of sufficient intensity to topkill woody shrub species would occur only once per 100 to 200 years for the Balsam Mountains area in North Carolina. Man-caused fires, however, are 5 to 10 times more frequent than lightning fires and 50 percent of these are estimated to be of high intensity.

Comparing species that develop on continuously disturbed grazed areas with single disturbance burn scars, Lindsay and Bratton (1979a) concluded that infrequent large lightning fires if allowed to burn would probably not maintain grassy balds on the Great Smoky Mountain National Park. They compared species composition differences between several types of high elevation disturbed sites. These areas included natural grassy balds, fields cleared by settlers, and burn scars from large logging slash fires. Species found on cleared fields were similar to those on natural grassy balds. Both were dominated by mountain oat grass (Danthonia compressa); followed by sheep sorrel (Rumex acetosella) and dwarf cinquefoil (Potentilla candadensis). Introduced species (exotics) ranged from 2 percent (spruce-fir balds) to 16 percent (oak forest balds) on natural grassy balds and 11 percent on cleared fields. Burn scars were dominated by thornless blackberry (Rubus canadensis), while mountain oat grass was very infrequent, and only 3 percent of the species were exotics. Lindsay and Bratton stated that the continuous disturbance from cattle grazing on natural balds (for approximately 150 years) and on cleared fields (for approximately 60 years) promoted trampling resistant mountain oat grass. Without grazing mountain oat grass decreased in importance while other herbaceous species (dependent upon the elevation of a particular bald) increased in importance. Burn scars differed because disturbance was not continuous; grasses did not commonly become established, and succession proceeded to forest types.

Barden (1978), examining the effects of prescribed fire on woody species regrowth, found that prolific sprouting species that are not heavily utilized by browsers (deer and rabbits) such as lowbush blueberry (Vaccinium vacillans) and southern bush-honeysuckle (Diervilla sassilifolia) recovered to preburn coverage levels within two growing seasons following treatment. For a heavily browsed species such as highbush blueberry (*Vaccinium constablaei*), regardless of its prolific sprouting capacity, recovery to preburn coverage would take 10 to 15 years. He found that mountain laurel (*Kalmia latifolia*) and minniebush (*Menziesia pilosa*) were favored most by browsers and were slowest to recover following prescribed burning. Barden estimated that low intensity prescribed burning would have to occur every 5 years or less to control woody shrub species and maintain an open herbaceous community.

A 3-year prescribed burning cycle can effectively maintain stands of mountain oat grass (*Danthonia compressa*). Burning has been found to eliminate the mulch layer that develops in undisturbed mountain oat grass stands (Hillman and Murdock 1982). Lindsay (1977) also found that prescribed burning only every 2 or 3 years will be needed to maintain grassy balds once sprouting tree and shrub species are effectively controlled and herbaceous species are well established.

Saunders, Ramseuer, and Smathers (1981) examined natural regeneration of a spruce-fir stand, on a steep rocky site with shallow soils, following a man-caused wildfire from the mid-1950's. They found that 25 years after the severe fire, a dense shrub layer developed consisting of southern bush-honeysuckle (*Diervilla sessifolia*), southern mountain-cranberry (*Vaccinium erythrocarpum*), thornless blackberry (*Rubus canadensis*), and common highbush blueberry (*Vaccinium corymbosum*); while the tree layer was relatively open and comprised of Fraser fir (*Abies fraseri*), followed by yellow birch (*Betula lutea*), and fire cherry (*Prunus pensylvanica*). They concluded that severe fire slowed recovery of the site to a spruce-fir stand, and fire on this type site and of similar intensity could have produced heath balds.

Cain (1930) stated that of the three factors (windfall, landslides, and fire) that created and/or maintained heath balds, fire was the most important factor. Fire resistant species such as Mountain laurel (*Kalmia Latifolia*), Purple rhododendron (*Rhododendron catawbiense*), and blueberries (*Vaccinium* spp.) readily resprout following fire and effectively prevent tree species migration into heath balds.

Prescribed fires used by the National Forests in North Carolina on heath balds have topkilled up to 100 percent of the shrub species; most species sprouted heavily following treatment (Lindsay 1977).

2. Effects of Mechanical Methods

a. Forest

Mechanical methods are not used frequently in the Southern Appalachian mountains because areas of sustained gentle slopes are relatively small and widely dispersed. During 1986 and 1987, only 4 percent (approximately 5,400 acres) of all vegetation management treatments used mechanical tools. Little to no research has been done on effects of mechanical tools on Appalachian mountain sites. Use of these tools is expected to produce similar results to their use on Piedmont and Coastal Plain sites.

Injury and Mortality

Mechanical methods can injure or kill vegetation. Mechanical tools, in increasing order of intensity, are: mowing, chopping, shearing, scarifying, ripping, piling, raking, and disking.

Shearing and mowing tools cut only the above ground portions of plants. They effectively kill species, such as most pines, that do not have the capacity to resprout. Piling tools are normally used after stems have been sheared or manually cut. Mortality is low as long as plants are not uprooted.

Chopping tools cut above ground stems, but they also can sever plant roots or rhizomes (horizontal stems below ground). Blade cutting depths can range from 1 to 10 inches depending on the size and weight of the choppers. When root systems are not severely damaged, sprouting species quickly recover.

Significantly higher injury and mortality occur with more intensive raking, disking, ripping, and scarifying tools because more rootstocks are affected. In central Alabama, Miller (1980) determined that shearing and raking material into windrows is more effective than chopping to control sprouting. He reported 25 percent fewer sprouts on windrowed compared to chopped sites two growing seasons following treatment.

Mechanical methods effectively reduce or control woody and herbaceous competition, permitting increased survival and growth of planted pines and hardwoods.

Competition

On a lower piedmont site, Edwards (1986) observed that more intensive treatments were more effective in reducing competition, producing greater seedling survival after the first growing season and the best height growth responses at the end of two growing seasons. Slay and others (1987) in north Louisiana did not find significant differences in survival; all treatments produced acceptable survival. They did, however, note the relationship between amount of competing vegetation reduction and seedling growth response.

Treatments that are combinations of tools are generally more effective in competition control. Stransky and Halls (1981) compared burning, chopping and burning, and a treatment consisting of shearing, raking, burning, and disking on east Texas loblolly pine-shortleaf pine-hardwood sites. The latter, which is the most intensive, provided the greatest amount of competition control and produced significantly greater tree growth than the other two treatments. Chopping and burning produced the next highest response, followed by the burning only treatment.

Growth Response

Increases in seedling survival and growth have been reported for scarifying tools through the creation of improved microsites, providing nutrient pools near the seedlings, and the control of competing herbaceous vegetation (Alm, Long, and Eggen 1988).

In one study on a Ouachita Mountain site, ripping caused no effect on first or second year survival of loblolly pine, but provided increased soil moisture in the upper 4 inches of soil. By the end of two growing seasons, ripping increased total seedling height by 10 percent (Wittwer, Dougherty, and Cosby 1986).

Stafford, Torbert, and Burger (1985) showed significant loblolly survival, height, and diameter growth responses with shearing, raking, or disking treatments on piedmont plateau sites. In their study all disking treatments increased early growth from what they attributed to relieving compacted soil conditions. Mann and Derr (1970) have also shown consistent positive growth responses for loblolly pine.

Scholz (1955) found that seedbed preparation by disking under a mixed oak overstory more than tripled northern red oak regeneration. The treatment was applied prior to seedfall during a good acorn crop year. Disking has also improved survival and growth of planted hardwoods. On bottomland hardwood sites in western Mississippi, Kennedy (1981a, 1981b) compared mowing and disking treatments with a no treatment control plot for sycamore, green ash, nuttall oak, sweet pecan, cottonwood, and sweetgum. He found that disking provided hardwoods with additional water and nutrients by controlling vines and weeds. Seifert, Pope, and Fischer (1985) compared the effects of disking, disking and bedding, and a no treatment control on planted swamp chestnut oak. Survival did not differ between the two methods, but survival with no treatment was 15 percent lower than either method. Disking has also doubled the amount of survival, and increased height growth of cherrybark oak by 18 percent (Woodrum 1983).

Growth losses can occur from piling and raking treatments when nutrient displacement occurs. Swindel, Conde, and Smith (1986) found that tree height, basal area, and volume were smaller for trees not growing near or adjacent to windrows. They attributed this to the accumulation of soil and litter in the windrows.

Several studies have shown that by age 13 to 15 years the advantages provided by low to high intensity mechanical treatments are no longer significant for pine diameter, height, or volume growth (Buford and McKee 1987; Haywood 1980, 1983; Tiarks 1983).

Species Composition

Shifts in species composition are caused by use of mechanical methods. Mechanical treatments reduce woody species and increase herbaceous species temporarily. In general, the more intensive a treatment the greater the shift in species composition.

Lewis, Tanner, and Terry (1987) noted that mechanical methods reduced woody species coverage but that overall species composition was not affected. Miller (1980) also determined that while tree, shrub, and vine species were 55 percent smaller on windrowed areas compared to chopped areas, there were no differences in overall species composition. Both areas had approximately 118 herbaceous and 15 grass species.

Comparing burning and disking treatments Buckner and Landers (1979) determined that herbaceous annuals and perennials are favored by disking. After one growing season single disked areas had better herbaceous growth and production than double disked areas, but during the second year the double disked areas yielded more herbaceous food plants and seed than even annually burned plots.

Successional Patterns

Longer term effects from mechanical methods are successional changes over time. Mechanical treatments can result in vegetation dominated by herbaceous species and provide early growth advantages to desired pine and hardwood species. Greater changes to vegetation occur with more intensive mechanical methods and recovery is slower. Depending on intensity, woody species recovery occurs 5 to 10 years following treatment.

Research has shown that following harvest and site preparation by low to high intensity mechanical methods, herbaceous species temporarily increase while woody species temporarily decrease. One study by Conde, Swindel and Smith (1983a) showed that by the second year after harvest and site preparation by chopping and bedding, herbaceous species dominated the site but woody species were beginning to recover. Their conclusions were based on measurements of woody and herbaceous species cover, frequency, and biomass. A more intensive mechanical treatment consisting of prescribed burning, shearing, piling, disking, and bedding, produced similar results but succession was set back further (Conde, Swindel and Smith 1983b). Woody species recovery was slower but after 2 years it was beginning to increase. After 5 years the lower intensity treatment area (chopping, bedding) was again dominated by woody species while succession on the higher intensity treatment area (burning, shearing, piling, disking, bedding) was proceeding towards a woody species community but was still dominated by herbaceous species.

Impacts from burning, chopping, shearing, and raking were analyzed by Stransky, Huntley, and Risner (1986). They found that 1 year after mechanical site preparation herbaceous species increased and woody species declined, with less decline on chopped than sheared and raked areas. After 3 years, herbaceous species peaked and woody species were almost back to pretreatment levels. During the 5- to 10-year period after treatment, herbaceous species declined as they were shaded out by the pine and hardwood canopy closure. Ten years after treatments, woody species had fully recovered.

Mechanical treatments are more effective than other methods, such as fire, in reducing woody species (Moore, Swindel, and Terry 1982; Stransky, Huntley, and Risner 1986) and mechanically treated areas are slower to recover to pretreatment levels than other methods (Lewis, Tanner, and Terry 1987).

Appalachian
untain Balds

Mowing of balds maintains them in an early successional stage dominated by herbaceous species. Scarifying, ripping, and disking tools have been used to restore grassy balds that have become overgrown with heath and other woody shrub species. Mechanical methods generally favor grasses and retard woody species development. Mowing is most effective on grassy balds with low amounts of woody species, which are easily accessible, and have few rocks and gentle terrain (Hillman and Murdock 1982).

Mowing during the dormant season seems to increase the number of locust and blackberries (Thomas 1986), while growing season mowing appears to reduce them (Haskell 1986). Reducing blackberries increases the grassy community. Dormant season mowing becomes ineffective once woody species such as black locust and blackberry have become established and may actually stimulate sprouting and spread of these species. Repeated mowing (every 3 weeks) during the active growing season to control locust and blackberry sprouting was found to reduce woody and most herbaceous vegetation biomass and increased grasses (Haskell

1986). Early summer (growing season) mowing following burning may greatly reduce the number of goldenrod (Komarek no date). Mowing will not reduce mulch produced by mountain oat grass, so plant communities may change over time (Hillman and Murdock 1982).

Lilly (1980) found that the combination of fall mowing followed by growing season burning would promote blackberries and reduce black locust.

Cocking, Baxter, and Lilly (1976) studied the use of prescribed fire as an alternative to mowing on the Big Meadows site of Shenandoah National Park. Big Meadows is an open grassland community with extensive woody encroachment. At the time of the study, it had been maintained by annual fall mowing for 10 years. A less desirable woody species community consisting of blackberries and black locust was persisting over a more desirable herbaceous species community. Their study of an early spring prescribed burn (mid-April) found no difference between burning and mowing; both treatments individually were effective in reducing woody species growth. However, by the end of the growing season following either burning or mowing, blackberry cover had recovered to or exceeded no treatment levels, while a combination of mowing and burning sustained a reduction of blackberry cover. For black locust control, however, either mowing or burning were found to be effective in reducing black locust cover. They concluded that prescribed burning could be effectively substituted for annual mowing but that a combination treatment of burning and mowing or additional spot treatments by other methods may be necessary to control some woody species like blackberry which may be increased by either burning or mowing alone.

3. Effects of Herbicides

a. Forest

Herbicides are designed to injure or kill plants. The effect of a specific herbicidal treatment, however, is the result of many interacting factors including: initial vegetation onsite; selectivity of the herbicide and application method used; pattern in which the herbicide is applied; biochemical effects of the herbicide on vegetation; and timing of the treatment (Gjerstad and Nelson 1986; Norris 1981; Smith 1966). General discussion of vegetation effects is found below; further discussion of tools and herbicides is found in chapter II. Unless otherwise noted the following information about uptake, movement, and effectiveness of herbicides is from the 5th Herbicide Handbook of the Weed Science Society (1983).

Herbicides can be broadcast or more selectively applied. Broadcast application achieves uniform distribution of herbicide. Aerial and ground-mechanical applications of granular or liquid products are generally broadcast. Broadcast application is commonly used for site preparation, release, and rights-of-way maintenance (Cantrell 1985). Selective methods allow for incomplete area coverage or application to specific targets. Hand applications are generally target or spot specific (Williamson and Miller 1987). Directed foliar sprays, cut-surface treatments, and basal stem treatments are target selective; spot around and basal soil spot treatments are less so; grid soil-spot, banded foliar, and many herbaceous weed treatments are the least target specific of the selective methods. More selective application patterns have less risk of affecting non-target vegetation than broadcast applications. They are commonly used for site preparation, release, precommercial thinning, ROW maintenance, wildlife habitat improvement, and weed control in recreation areas.

Injury and Mortality

Rates of uptake and time until the first effects show vary with species, product, and environment (Gjerstad and Nelson 1986; Norris 1981). Dicamba, fosamine, 2,4-D and 2,4-DP are taken in through leaf, stem and root tissue (Kitchen, Rieck, and Witt 1980; Weigel, Beyer, and Riggleman 1978). Imazapyr and picloram enter either through the roots or leaves. Hexazinone and tebuthiuron are taken in primarily through the roots with some entering through leaves (McNeil, Stritzke, and Basler 1984). Sulfometuron methyl primarily enters through leaves, but there is some root uptake. Glyphosate and triclopyr enter primarily through leaves.

Some plant surfaces are designed to selectively protect the plant (bark on stems, wax on leaves) (Norris 1974). Penetration of these surfaces is enhanced by using additives such as diesel oil, kerosene, limonene, or mineral oil. Thickness of bark on stems or wax on leaves influence the effectiveness of a herbicide treatment even when an additive is used.

Once a herbicide is taken into a plant, it may move through plant tissues. Many herbicides concentrate in growing tissues and disrupt normal functioning. Some disrupt photosynthesis (glyphosate, hexazinone, and tebuthiuron), some interfere with amino acid synthesis (imazapyr) (Peoples 1984), and others (dicamba, fosamine, picloram, sulfometuron methyl (duPont 1982), triclopyr, 2,4-D, and 2,4-DP) interfere with growth processes such as cell enlargement, cell reproduction, or bud formation and enlargement.

Translocation of herbicides in the plant generally follows the normal food movement system. Dicamba, glyphosate, picloram, and triclopyr are translocated up and down in plants, accumulate in plant roots or root collars, and effectively suppress sprouting from stumps (Lewis, Zedaker, and Smith 1984; Troth, Lowery, and Fallis 1986; Warren 1980). Fosamine inhibits bud formation and growth, and is practically immobile; thus it can be used to chemically prune only a part of a plant (Coupland and Peabody 1981).

Some herbicides are broken down by plants. Limited information is available about the chemical breakdown products and their effects (Chrzanowski 1983; McNeil, Stritzke, and Basler 1984; Sung, South, and Gjerstad 1985). Primary concern thusfar has been to determine and report what these degradation products are and how rapidly they ar further decomposed. Herbidical, toxicological, or biochemical properties are, as yet, virtually unreported.

Plant Susceptibility

Effectiveness of herbicides varies among plant species. Dicamba, 2,4-D, 2,4-DP, picloram, fosamine, and triclopyr are used to control woody species and broadleaf weeds. Glyphosate, hexazinone, imazapyr, and tebuthiuron are effective against grasses, woody species, and broadleaf weeds. Sulfometuron methyl is used primarily to control weeds and grasses.

Some herbicides are essentially ineffective against certai plants. Though effective against most hardwood species, hexazinone has virtually no effect against yellow-poplar. Imazapyr gives limited control of locust, redbud, blackberry, and most legumes.

Some plants or groups of plants are extremely difficult to control. Glyphosate is fairly effective against sedges;

picloram and dicamba are commonly used to control kudzu. Tebuthiuron is also used for kudzu control on non-forest sites (Miller 1986).

Grapevines can become a management problem in hardwood stands. If the vines form an arbor over the tree crowns, they can severely damage or kill trees. Bending and breaking of stems and branches can result from the weight of the vines, especially when ice forms on them. Also, grape leaves can form such a solid mass that trees can be killed when shading interferes with the photosynthetic process.

Grapevine control is recommended for better hardwood sites (oak site index 60+) where there are 40 or more grape stems per acre (Smith 1984). Manual control of established vines is effective in stands with a closed canopy where shading is sufficient to prevent successful resprouting of the shade intolerant vines. However, if a thinning or harvest is planned within 3 years of a grapevine treatment, increased sunlight from canopy opening will permit grapevines to prolifically resprout, and herbicide treatment may be needed for adequate control.

Herbicidal control of grapevines (either by basal spray, or cut surface treatment applied to stumps of freshly severed vines) is generally successful in controlling established vines which otherwise would have sufficient sunlight to resprout (Smith 1984). Best control is achieved when vines are treated during early March or mid-September. Herbicide treatment within 3 years preceding any harvest protects regeneration areas from being overgrown by grapevines. However, these treatments do not control germination of grape seed, so some site reinvasion is to be expected.

Effects of herbicides also depend on season of application (Gjerstad and Nelson 1986; Norris 1981). Fosamine, which blocks spring bud break, is a very slow acting herbicide which is generally fall-applied; effects are usually not seen until the next spring. Spring or early summer foliar applications of dicamba, 2,4-D, 2,4-DP, and hexazinone are effective in controlling many woody species while application of picloram, sulfometuron methyl, tebuthuiron, or triclopyr is done in the spring, summer or fall (excluding droughty periods). Cut surface treatments are made throughout the year.

Several herbicides are soil active; once in the soil they can be taken up by plants. Hexazinone and tebuthiuron are currently produced in formulations labeled for soil application. Dicamba, imazapyr, picloram, sulfometuron methyl, triclopyr, 2,4-D, and 2,4-DP also have some soil activity. Non-target plants may be affected if they are within the treated area or if their roots grow into it. Hexazinone remains active in the soil for 2 weeks to 6 months; imazapyr and tebuthiuron remain active longer (appendix A). Labels of products containing tebuthiuron carry the warning that the product is "...a very active herbicide which will kill trees, shrubs and other forms of desirable vegetation having roots extending into the treated area." (Elanco 1986). This effect persists significantly longer than a growing season in the South but less than the five years reported in arid climates.

Mineral oil has been shown to increase the susceptibility of target grass to herbicidal activity without decreasing the target-selectivity of the herbicide (King and Handley 1977). It has also been shown to improve the effectiveness of glyphosate in eliminating established Rhododendron cover from a site (Tabbush and Sale 1984).

Reproductive Success

Herbicides evaluated do not appear to affect seed biochemistry or germination rates (Prasad 1984). Soil active herbicides do, however, affect young seedlings emerging from seeds in treated areas. Persistent soil-active herbicides can cause a temporary shift in types of vegetation growing on a site.

Use of mineral oil may affect flowering and seed set by non-target plants. While forest related data is unavailabl there is some international literature which relates to fruit and nut trees. Liotta and Maniglia (1979) report tha mineral oil negatively affected 1.0 - 1.5 cm tangerine initials, anthough both flowers and larger fruit (3.0 - 3.5 cm) was unaffected. Moss (1976) reports a reduction of flowering by sweet orange when mineral oil was applied during the period of flower induction. Procopiou (1973) reports that a dormant spray of mineral induced earlier flowering of cultivated pistacio. These results indicate that mistimed application of mineral oil could negatively affect seedfall.

Growth Response

Seedling survival is reported to improve after herbicidal site preparation in many studies. Ferguson (1958) reports the best survival of loblolly pine seedlings when all hardwoods over 1 inch d.b.h. were controlled. Natural seedling establishment is reported to be most satisfactory after broadcast herbicidal site preparation (Loyd, Thayer, and Lowry 1978). Similar results are reported for yellow poplar, white pine and loblolly pine (McGee 1980b), for sweetgum (Morrissey and Ezell 1975), and for black cherry (Horsley 1981).

"No effect" on survival from herbicidal site preparation has, however, also been reported. Various southern yellow pines have been unaffected (Harrington 1960; Hatchell 1964 Plass and Green 1963; Williston and Huckenpahler 1958) as have white oak (Plass and Green 1963), eastern white pine (Plass and Green 1963; Sterett and Adams 1977), black walnut (Todhunter and Bieneke 1979), and eastern redcedar (Williston and Huckenpahler 1958). Morrisey and Ezell (1975) report a decline in oak regeneration as site preparation increases.

Mineral oil has been reported to temporarily reduce (1-7 days) net photosynthesis when applied to pecan leaves (Wood and Payne 1986). This is considered to be a minor impact on non-target vegetation since the greatest potential for its use is in streamline application (not foliar spraying).

Herbicidal site-preparation, broadcast or more selectively done, is reported as having beneficial effects on both height and diameter growth of hardwoods and conifers (Byrd and Foster 1982; Gjerstad, Nelson, and Minogue 1984; Holt and Nation 1974; Lowery 1986). Selective herbicidal site preparation can be done pre-harvest (within 3 years) to open the understory and permit seedling establishment prior to harvest (Loftis 1985). Pre-planting selective stump treatment allows control of undesirable sprouting. Done in conjunction with specific silvicultural systems, these processes influence species composition in the subsequent stand (Horsley 1982).

Fitzgerald and others (1975) and Freeman and Van Lear (1977) report that herbicidal site preparation for eastern white pine is effective only in conjunction with clearcutting; any residual overstory decreases treatment effectiveness.

While most papers indicate only limited between-treatment differences where herbicides were used, several report comparison of herbicide methods with other treatment methods. In naturally regenerating stands Cain (1983) reports that a mow-and-disk treatment resulted in greater loblolly and shortleaf pine seedling density than mow-and-herbicide treatments. Maple (1965) reports that a rotary brushcutter treatment resulted in better stocking than either fire or herbicide treatments (though the latter were still significantly better stocked than control plots). In planted stands, Carter and others (1975) report no significant difference between burning and tree injection and shearing, piling, disking, and bedding; injected plots had slightly lower stocking, offset by slightly better height growth. They also report that aerial spray did not result in stocking or growth comparable to the tested mechanical treatments (sheared, piled, and bedded; sheared, piled, and disked; and, sheared and burned), but aerial treatment was less expensive and provided better wildlife habitat. Haines (1981) reports burning and chopping to be more effective than burning or chopping alone, herbicide, or herbicide and burn treatments.

Wittwer, Dougherty, and Cosby (1986) report that a preplant combination of ripping followed by band application of hexazinone to soil increased height and diameter growth of loblolly pine seedlings planted in southeastern Oklahoma. The combined treatment had greater beneficial effect on both height and diameter than indicated by the effects of each treatment alone. Improved water conditions and the reduction of competition, still evident at the end of the second growing season, are credited with the improved growth.

Release treatments which involve herbicides, either broadcast or more selectively applied, are reported to be highly effective in improving growth of desired pine or hardwoods (Grano 1970b; Knowe and others 1985; McConkey 1958; Michael 1980, 1985; Wendel and Lamson 1987; Yeiser 1986; Zutter and others 1987). Herbaceous weed control, by increasing water and nutrients available to pine seedlings, is reported to generate significant increases in survival and growth of planted pine seedlings (Glover, Knowe, and Gjerstad 1981; Nelson, Zutter, and Gjerstad 1985; Whipple 1962). Herbicidal release can be the difference between successful or unsuccessful pine planting (Wilson n.d.).

Several authors state that degree of release is critical to treatment success. Clason (1978) suggests that removal of either hardwoods or herbaceous competition alone is less effective than controlling both. Elwell (1966) found that a single herbicidal treatment to release shortleaf pine from hardwood competition was as effective as repeated treatments

Papers by Russell (1971) and Walker (1954) stress the importance of treating during the first growing season. While stressing the importance of first season treatment Russell (1969) indicates that treatment of shortleaf pine can be deferred (in the Cumberland Plateau) up to two years. Delay results in significant loss of potential growth. Ferguson (1958) and Bower and Ferguson (1968) stress the importance of rainfall to treatment success. Williston and McClurkin (1961) and Zutter, Glover, and Gjerstad (1986) specify soil moisture as one critical element in effecting release.

Several papers report that stands failed to respond to herbicidal release. Speculation as to why there was no response center on damage to the residual trees during application and site characteristics including water relations and competing vegetation onsite (less competitio at outset equals less effect from treatment; Campbell 1987 Dierauf 1977; McClay 1955; Ponder and Schlesinger 1984; Russell 1971).

Herbicidal TSI treatment (pine or hardwood stands) to eliminate competing species improves stand vigor and quali

(Miller, Wray, and Mize 1987). Haines and Davey (1979) report that in a study to measure growth response (as total loblolly pine biomass produced) the most pronounced treatment effects were obtained with the use of herbicides. Cain (1985a) reported that chemical treatments were more effective than prescribed burning for reducing hardwood density in a stand being managed for pine sawlog production and that the reduction was still evident 23 years after treatments were discontinued. Age of stand (especially for shortleaf pine) is a significant factor in treatment effectiveness; older trees respond less well than younger ones (Williston and Balmer 1980).

Several excellent summary papers are available which contain information about growth effects following herbicidal treatments (Bey and others (1975; hardwoods); Cantrell (1985, general); Gjerstad, Nelson, and Minogue (1984, loblolly pine); Lowery (1986, shortleaf pine); Stewart, Gross, and Honkala (1984, general annotated bibliography); Williston and Balmer (1980, shortleaf pine)).

Species Composition

Broadcast application of a herbicide selective to woody species generally results in a vegetation cover composed of grasses, sedges and forbs. Species resistance to herbicide complicates this generalization. Target specificity of herbicides will influence the species composition of residual vegetation on a site.

Selective applications permit significant manipulation of vegetation. Species which are potential hazards due to height, noxious nature, or other consideration can be selectively controlled. Depending on the selection process, selective stand treatment can be used to favor almost any species.

Sterett and Adams (1977) reported that 3 years after herbicide release treatments pine growth had improved, and, although numbers of some (non-pine) species had declined there was a striking increase in the number of individuals of some species present, as well as the number of species present on the treated area. Scifres and Koerth (1986) report that, though initially affected, diversity and coverage by forbs were virtually unaffected 1 year after tebuthiuron application.

Use of hexazinone to deaden hardwoods, followed within four months by a prescribed fire (brown-and-burn) can be used to thin overstocked pine stands. Nickles, Tauer, and Stritzke (1981) report about 70% reduction in overstocked pine stands in southeastern Oklahoma with complete mortality of smaller diameter (1 inch or less) stems. This effect was greater than that seen on check plots. The additional leaf litter from the deadened hardwood is credited for the increase in fire effectiveness.

In a summary of 41 years of selection management in Arkansas, Baker (1986) presents management strategies necessary to regenerate stands and then to maintain stand productivity. In order to permit pine reproduction in these naturally mixed stands and achieve full mixed species stocking all mid- and over-story hardwoods were initially removed; periodic herbicide treatment was necessary to control understory hardwood; and, annual improvement cuts were needed to remove the poor quality pines and to improve stocking. In order to maintain the stand it was necessary to: (1) periodically control understory hardwoods (herbicides applied at 10-year intervals); (2) continue improvement and harvest cutting on a periodic basis (this was done annually for the first 35 years); and, (3) regulate stand structure by volume control (total volume cut roughly equal to growth since last cut). While selection management did permit gradual improvement in the stocking, accelerated growth of the best trees, and a gradual increase in the proportion of acreage growing high value sawtimber, it also was labor intensive (requiring annual improvement cuts) and also increased herbicide incursion (once every 10 years) in the treatment areas.

Successional Patterns

The chief difference noted between forest and ROW sites is frequency of treatment. On forest sites, herbicide treatment is done to temporarily favor a species or group of species at a specific point in its life cycle. Due to physical requirements ROW's are maintained (by repeated management activity) in an early successional stage. Type of plant cover varies greatly depending on the vegetation management technique used (Bramble 1962). Broadcast herbicide application permits maintenance of a low grass, forb and sedge community; more selective application permit maintenance of a slightly taller, shrubby community. For powerline ROW either broadcast or selective treatment may b used. Along roadsides and gas pipeline ROW's broadcast application is generally used to maintain a low-growing, grassy community. However, selective application may be used to favor species such as wildflowers.

There is no evidence that repeated typical applications of herbicide in ROW settings cause permanent effects on succession. Normal succession resumes within one to three years of last application of herbicide (Bramble and Byrnes 1982).

Information about additional effects of herbicide use in an environment already affected by industrial pollution, agricultural pesticide usage, and automobile emissions is unavailable. Herbicides are applied to individual even-age stands only one to three times (stand establishment and stand improvement activities) during the 60 or more years they are grown. Herbicide use rates in most Forest Servic applications are also very low relative to agricultural or other uses. However, managing uneven-aged stands of pine will require that herbicides be used more frequently to permit establishment of pine reproduction. A 5- to 10-year treatment cycle (which may include fire, manual or mechanical tools) will be necessary (Wenger 1984).

b. Appalachian Mountains Balds

Herbicide treatment on mountaintop balds is limited primarily to control of invading herbaceous plants, such as blackberry, and control of sprouting from stumps previously severed. Because of unique ecosytems, treatments are always done selectively. A herbicide and mechanical cutting study to control blackberries conducted on the Cherokee National Forest in 1987 indicated that Garlon appeared slightly more effective than Roundup in topkilling blackberries; however, significant resprouting occurred with both herbicides. Roundup appeared to cause less damage to grasses, sedges, and mosses on the treatment plots. Mechanical cutting of the plots was ineffective in controlling blackberries, but might be more effective if done in the growing season (see page IV-53).

Spot treatment of manually cut locust stumps with Garlon 3A was found to be successful in killing locust root systems (Haskell 1986).

4. Effects of Biological Methods on Appalachian Mountain Balds

Livestock grazing can injure or kill vegetation. Grazing also causes changes in plant growth response, and shifts in species composition.

Grazing maintains a low ground cover of herbaceous species, controls woody species encroachment through browsing, trampling, and removal protective cover for tree seedlings (Mark 1958).

Balds that have been disturbed primarily by grazing have a higher abundance of mountain oat grass (Danthonia compressa), and three-toothed cinquefoil (Potentilla tridentata), along with introduced grass species such as timothy (Phleum pratense), redtop (Agrostis alba), and Kentucky bluegrass (Poa pratensis); while ungrazed grassy balds are dominated more by sedges, such as the Pennsylvania sedge (Carex pensylvanica) and the necklace sedge (Carex debilis), along with the herb angelica (Angelica triquinata) (personal communication, Robert Sutter, N.C. Dept. of Agriculture).

Historically, grassy balds have been maintained by the grazing of cattle, sheep, horses, and goats. Goats are the most effective users of woody species, followed by sheep, horses, and cattle; however, goats and sheep are more susceptible to animal predation (Thomas 1986). Cattle do consume pine and hardwood foliage, and young new shoot and twig growth. Amounts consumed are minor since herbaceous species comprise the bulk of their diet. Plant mortality from direct consumption is low because rootstocks are normally not affected, and most woody and herbaceous species resprout.

Damage to pine and hardwood seedlings occurs from browsing and trampling. Damage can occur from browsing lower branches, and also by breaking lower branches by leaning or rubbing (Lewis, Tanner, and Terry 1987).

Herbaceous forage yields monitored over a 10-year period, on a Coastal Plain range site, were not significantly impacted by heavy utilization intensities as high as 60 percent of the current year's growth (Clary 1979; Pearson and Whitaker 1974a, 1974b).

Shifts in species composition occur from heavy grazing. Herbaceous species which comprise the majority of preferred livestock feed are most affected. Grazing can increase forbs and decrease grasses. Grazing suppresses most tree and shrub vegetation, maintaining an herbaceous ground cover. Some woody species such as buckeye and hawthorn are not eaten by cattle; therefore, their populations continue to expand on balds. Grazing can reduce species composition of balds significantly over time it is being grazed. The peak of species composition is probably reached some years after grazing ceases and prior to advanced succession (Great Smoky Mountains Field Research Laboratory 1983). When grazing ended on grassy balds, succession proceeded from a predominately herbaceous community towards one dominated by woody species (Bratton and White 1980).

A three-part study by Lindsay and Bratton (1979b) determined historic maintenance, present status, and management methods available to maintain the grassy balds of the Great Smoky Mountains National Park. Historic maintenance consisted of intense grazing with high numbers of a variety of livestock (cattle, sheep, goats, horses), with some manual cutting of tree species; burning was infrequent due to a lack of fuel on grazed areas. They concluded that for grassy balds on the Great Smoky Mountain National Park, grazing with some manual cutting would maintain balds, and be most historically correct; but considering costs and effects (fence construction, water catchments, aesthetic impacts, etc.), manual cutting and mechanical mowing; or manual cutting, burning, and mowing would be more practical.

Grazing would not be suitable on some balds due to the small size of the area to be maintained, inadequate access, and lack of forage producing potential (Hillman and Murdock 1982). Some other disadvantages include excessive erosion when high numbers of livestock are used, poisoning of livestock from Eupatorium in the fall, and treatment ineffectiveness when low numbers of livestock are used (Lindsay 1977).

5. Effects of Manual Methods

a. Forest

Injury and Mortality

Manual methods can injure or kill vegetation by completely severing or girdling woody stems. Most hardwood species and woody shrubs that resprout are usually injured. Most pine species that do not resprout are usually killed.

Non-target vegetation can also be injured or killed when woody shrubs or trees being felled fall onto or cover other stems. Loss of stems selected to remain can be significant. Bernstein (1981) found that 31 percent of conifers in a release project were damaged or covered by slash. A significant risk of injury and mortality in young pine or hardwood plantations exists from the buildup of hazardous fuels from manual release and precommercial thinning projects. This risk is highest for precommercially thinned stands approximately 1 to 6 months after project completion.

Wounds caused by felling woody shrubs or trees onto remaining stems create entry points for insects and disease organisms which may eventually cause stem mortality. In the upper piedmont of Georgia, Miller and Phillips (1984) observed that stumps from chainsaw treatments for hardwood site preparation produce sprouts with higher risk of decay and poorer anchorage than mechanically sheared stumps, because the sprouts originate higher on the stumps and closer to cut surfaces.

Incomplete severing or girdling of target vegetation which does not cause immediate mortality might weaken individual stems and cause mortality several seasons later. A study by Cody and Burns (1976) in New York State showed that a single chain saw girdle was effective in removing unwanted hardwood vegetation (90 percent mortality), but mortality occurred over four growing seasons.

Trimble and Tyron (1976a; 1976b) state that as grapevines grow into the tops of young trees, limbs and crowns can be broken and stems can be bent or twisted. Potential for ice and snow damage increases, and interference with photosynthesis can occur when tree foliage is covered. They found that manual grapevine control, under an overstory canopy that shaded severed vines, took 3 years to be effective. Sprouting occurred during the first 2 years following treatment, but by the third growing season vines were killed. Smith (1984) found that although grapevines sprout prolifically and grow rapidly, where the overstory canopy is sufficient to shade out grapevines, sprouts will die within a few years. For areas planned to have a heavy thinning or a regeneration cut, Smith recommends manual severing, near the groundline, of vines growing in or over tree crowns at least 4 to 5 years prior to timber cutting. In young stands he recommended no treatment until canopy closure which usually occurs once trees are approximately 15 feet tall (8-10 years old).

Growth response

Manual cutting tools are highly selective and can be used year round on all landtypes, but repeated treatments, either annually or even more frequently, may be necessary to adequately control woody competition (Lowery 1986). Species which resprout can quickly reoccupy treatment sites, and height growth of sprouts can exceed that of natural and planted seedlings (Miller and Phillips 1984). On moderate to highly productive sites several repeated treatments may be needed to successfully release desired species.

When crop-tree release of Appalachian hardwoods is needed, Smith and Lamson (1983, 1986) and Smith (1979, 1981) recommended manual release when the codominant seedling origin stems are at least 25 feet tall. At that time the potential of tree sprouts to outgrow released crop-trees and the ability of cut grapevines to regrow into tree crowns is reduced.

Long-term effects of manual methods on vegetation are negligible. Sprout growth and crown closure rapidly reoccupy the site.

b. Appalachian Mountain Balds

Manual methods can effectively control tree species encroachment on grassy balds and heath balds but does not effectively control heath species encroachment (Lindsay and Bratton 1979b).

Additional treatments will be necessary on balds where sprouting species such as hawthorns, serviceberry, and red oak are manually treated; no additional treatments are usually needed on balds where nonsprouting species such as eastern hemlock, red spruce, and Fraser fir occur (Lindsay and Bratton 1979b).

Disadvantages of manual treatments include slash disposal, cost of treatments, and resprouting of most woody species (Lindsay and Bratton 1979b).

D. WILDLIFE

Effects of vegetation management on animals can include physical injury or mortality, and short-term and long-term habitat alteration.

Injury and Mortality

Death may result from the toxic effects of herbicides, effects of prescribed fire, or from mechanical, manual, or biological treatments applied to a site when animals are present.

Habitat Alteration

Wildlife habitat is the food, water, and cover that an animal needs to survive. Each species is adapted to a unique arrangement of these elements. The distribution of different ecological types and progression of successional stages through time provides these habitats. As habitat changes, so does the variety and abundance of wildlife species.

Vegetation management affects each species' habitat in a different way, benefiting some and harming others. For instance, when natural succession is retarded, species which need early successional stages usually benefit. Vegetation management also affects wildlife when it influences a key habitat element such as food or a place to breed. For example, site preparation may increase or reduce the number of snag trees available for cavity nesting birds. Or numbers of soft-mast producing plants may be reduced by application of herbicides or increased by a mechanical method which encourages sprouting, such as chopping.

Structural diversity of vegetation is probably the most important factor in determining wildlife species composition and abundance (Harris, Hirth, and Marion 1979). Prescribed underburns, for example, alter vegetation structure and composition by reducing woody understories and increasing ground vegetation. This action benefits species such as white-tailed deer by providing more desirable food sources but may degrade the habitat of songbirds like hooded warblers (Wilsonia citrina) which use woody understory.

To keep the effects of vegetation management in perspective, it should be stressed that most vegetation management occurs after habitat has already been substantially altered by timber harvest or regeneration. Silvicultural system (intermediate thinnings, or final harvest; distribution, size, and shape of regeneration areas; rotation age; retention of old-growth) streamside management zones, erosion control, road construction, and other management practices prescribed in Forest Land and Resource Management Plans (and outside the scope of this document) are likely to have a greater impact on wildlife abundance and species composition. Harvest of a mature pine stand, for example, tends to have a more significant effect on wildlife species occupying the site than subsequent site preparation or intermediate treatments which interrupt or accelerate the process of succession.

When vegetation management practices in combination with timber harvest and other management practices are applied in a forest, a variety of vegetation types and structure results. Over time, a mosaic of trees is spread across the forest landscape and habitat is provided for many different species of animals. This cumulative effect increases over-all or "among-stand" wildlife diversity even though "within-stand" diversity for a particular site may decrease.

Many treatments (pine release by herbicide, for example) are applied only once to a site. More long-term effects occur when more than one treatment (such as chainsaw, stump-spray, and prescribed burn) is applied to the same site. Since this normally occurs only once in the life of the stand, long-term impacts are not as likely as when stands are treated repeatedly. An example of multiple and repeated treatments is site preparation by KG blade, windrow, and prescribed burn followed by herbicide release at age 3, and prescribed burning on a 5-year cycle beginning at age 10. This sort of periodic treatment is effective in relegating many hardwoods to the understory. Although many hardwoods survive, many important species do not reach the age or size necessary for mast production or creation of nest cavities. In addition, periodic burning tends to remove downed woody material which provides habitat for reptiles and amphibians and eliminates accumulations of tops and brush which are used for cover by species like cottontail rabbits (Sylvilagus floricanus). However, burns also provide a continuing source of new den sites, downed vegetation, and brushpiles when living trees are killed by fire.

More research is needed into long-term effects on animals associated with plant communities treated with specific combinations of herbicides and periodic fire. Ongoing research and vegetation classification and inventories planned for the Southern Region will help fill some of these gaps.

1. Effects of Herbicides

Source of Information

Information sources for assessing the risk of direct toxic effects to wildlife are the same as for the human health risk assessment discussed in section B of this chapter. Three sections of the risk assessment apply to the analysis of risk to wildlife species:

- Section 6 (the hazard analysis) documents basic toxic properties of the herbicides and additives.
- Section 7 (the exposure analysis) documents probable exposures to these chemicals of terrestrial animals.
- Section 8 (the risk assessment) combines predicted hazards and exposures, and estimates danger to these animals.

Unless otherwise noted, information presented here is derived from the Risk Assessment (chapters 6-8, appendix A). Literature citations for specific points are found in that appendix.

Hazard Identification

Hazard is evaluated based on dose/time relationships. These relationships and their effects are the same as for human health: acute toxicity, subchronic toxicity, chronic toxicity, mortality, and organ effects.

Exposure and Dose Response

Exposure considerations include where the animal lives, how it moves and feeds, external characteristics of the animal (hair, feathers, scales), rate of herbicide application, size of treatment area, the way the herbicide was applied, and physical characteristics of the herbicide (persistence or drift potential). Exposure is estimated for three different situations:

The **typical** situation (the "realistic" scenarios in wildlife sections of the risk assessment) estimates average exposure of animals that may be reasonably expected during routine operations.

The **maximum** situation ("extreme" scenarios in wildlife sections of the risk assessment) estimates worst realistic exposures to animals when highest rates of herbicide are applied.

An **accident** situation estimates the direct exposure of animals to herbicide which might result from a spill o cans from a truck or a helicopter tank dump into water

Risk is a function of dose, which is critically dependent o many interrelated factors. Changing any of the factors modeled when predicting risk will change the dose and the potential effects on animal health. Estimates were also made of indirect exposures due to surface, subsurface, or airborne movement of the herbicides and additives in the environment.

Exposure Information

Because toxicological data are unavailable for most species occurring in the Appalachian Mountains, a set of species was chosen to represent animals from a variety of habitats and dietary needs. Terrestrial mammals, birds, amphibians, reptiles, and invertebrates were selected. Since laboratory tests are not normally done on wildlife species, it was necessary to evaluate several of the representative species by using data for similar animals fo which tests have been done.

Herbicide skin contact, inhalation (breathing), and ingestion (eating) are the exposure routes evaluated. Exposure rates were estimated for typical and extreme application rates for ground applications.

The typical setting assumes that animals seek cover during mechanical application and exposure is limited to contact with and ingestion of herbicide on or in leaves. The extreme case assumes that the animal is sprayed. In both cases, mammals and birds are assumed to ingest herbicide while preening after touching treated vegetation.

In the typical case, the amount of herbicide-contaminated food is taken to be a percentage of the diet (based on the size of the animal's feeding territory). In the extreme case all food is assumed to be contaminated.

Total exposure is estimated by adding exposure by all rout (appendix A, section 7).

Risk Description

Calculations of risk are based on a theoretical dose to animals in each typical, maximum, and accident situation. Risk is evaluated using EPA standards (EPA 1986a). Predicted risk is compared with published standards to see if the herbicide or additive poses a greater or lesser risk. Practices which reduce risk to a level lower than the standard are noted as management requirements or mitigating measures in chapter II.

Inert Ingredients

See discussion in chapter IV, section B.

Data Gaps

When assessing herbicide effects on wildlife, we face an overwhelming number of species with data gaps and inconsistencies in data. Regulatory requirements (40 CFR 1502.22) described in the human health section (Chapter IV, Section B) are addressed in the wildlife risk assessment (appendix A, sections 6-8). Response varies greatly among species, and differences among species are significant even within the same taxonomic grouping such as bird or fish. Ideally, to analyze effects on a species, data should be from tests on that species or a closely related one. Table 8-15 in the risk assessment (appendix A) summarizes data gaps for several species of aquatic animals.

Data gaps which result in uncertainty about reasonably foreseeable significant adverse animal health effects include the following:

- Basic data about acute, subchronic and chronic toxicity are lacking for many animal groups; species-specific information is generally unavailable. Some acute toxicity data are available for mammals but are unavailable for several chemicals for birds, insects, fish, aquatic invertebrates, and amphibians.
- Data on animal exposure to herbicides are generally unavailable. Dermal penetration rates, risk of exposure, and probable rate of exposure are not available.
- Field studies on chemical residue levels in or on plants in treated areas are lacking for most herbicides.
- Carcinogenic and mutagenic potential are unreported for most chemical/animal groupings.
- Data on synergistic effects of herbicides and inert ingredients on wildlife are not available.
- Data on cumulative effects of herbicides on wildlife are unavailable.

- Data concerning relationships between specific chemicals and individual species' habitats are, for the most part, unavailable.

Filling data gaps is an extremely expensive process; individual tests cost between $50,000 (mutagenicity tests, etc.) and $2,500,000 (chronic toxicity tests, oncogenicity tests, etc.). As in the evaluation of human health effects, the Forest Service considers the accumulated costs of filling all of the data gaps prohibitive. Modeling is done to overcome missing or unavailable data.

The analysis of missing and incomplete data is a risk assessment. This approach "is firmly based in scientific considerations... is a process of weighing alternatives and selecting the most appropriate actions" (National Research Council 1983). The risk assessment process provides worst case analyses (extreme and accident scenarios) of reasonably foreseeable scenarios in which extreme exposure to herbicide occurs.

Throughout the analysis, data from tests on similar animals are used to estimate missing or incomplete information. Best conservative estimates were used. For example, a dermal penetration rate of 10 percent was assumed although it exceeds the most rapid rate of skin penetration reported.

a. Direct Effects

Acute Toxicity

All herbicides evaluated are rated slightly toxic or very slightly toxic to rats when eaten (acute oral toxicity) except for the amine formulation of 2,4-D, which was rated moderately toxic (appendix A, table 6-1).

Studies of acute oral toxicity in birds (generally mallards (Anas platyrhynchos) or bobwhite quail) showed all to be slightly or very slightly toxic except for 2,4-D (ester and amine) which was moderately toxic. No avian studies were available for 2,4-DP or limonene.

Diesel oil has been demonstrated to be lethal to chicken embryos at a very low concentration in a single dose (Weeks and others 1988a). At rates significantly higher than normal field application rates, reduced egg viability was demonstrated for dicamba, fosamine, picloram, 2,4-D (amine and ester) and 2,4-DP. This latter information is of concern in the accident scenario. No information was found for hexazinone, imazapyr, mineral oil, sulfometuron methyl, tebuthiuron, or triclopyr.

Using a scale proposed by Larry Atkins (University of California) all of the herbicides were rated relatively nontoxic (the least toxic category) to honeybees (Apis melliferu) except for dicamba (moderately toxic). The adjuvants limonene and diesel oil, however, were found to be highly toxic to honeybees. No information is available concerning the toxicity of kerosene or mineral oil to honeybees (appendix A). However, several studies report mineral oil to be toxic to a variety of insects (including scales, thrips and mites) and synergism with oil soluble insecticides is also reported (Johnson and Caldwell 1987; Moustafa and ElAttal 1985; Ochou, Hesler, and Plapp 1986).

Irritation

In addition to knowing the potential of a chemical to cause death, it is also necessary to know if it is an irritant to skin or eyes. The risk assessment presents data concerning the amount of each chemical which causes primary dermal or eye irritation.

Registration standards required under the Federal Insecticide, Fungicide, and Rodenticide Act were developed for the protection of humans and their environment. For humans a set of four classes has been developed to describe the effects on dermal and eye irritation. This same level of precision is not required for animals. Data presented in this section are for mammals; rats and rabbits are the chief test animals used to determine primary skin and eye effects, and are virtually the only ones tested so far.

Dermal: Dermal irritation was reported (appendix A) as follows:

- None: hexazinone, tebuthiuron, and 2,4-DP.
- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (or mild): dicamba, kerosene, limonene, mineral oil, picloram, and triclopyr ester.
- None to moderate: fosamine.
- Slight to moderate: triclopyr amine, and 2,4-D (amine and ester).
- Extreme: diesel oil.

Dermal exposure to diesel oil at a relatively high rate for three weeks caused death of the test animals. Dermal exposure to kerosene for 28 days at a rate significantly higher than expected in the field resulted in severe skin and liver lesions in rats. At one-half the rate that caused these undesirable effects, (a rate which is still significantly higher than expected in the field), no negative effects were observed (Weeks and others 1988a) due to kerosene dermal exposure.

Eye: Eye irritation was reported (appendix A) as follows:

- None: fosamine (Krenite), diesel oil, and triclopyr ester.

- None to slight: glyphosate, imazapyr, and sulfometuron methyl.
- Slight (mild): picloram, tebuthiuron, 2,4-DP, kerosene, and limonene.
- Slight to moderate: dicamba and 2,4-D (amine and ester).
- Moderate to severe: fosamine (Krenite S) and triclopyr amine.
- "Irritating": hexazinone.

No Observed Effect Levels

The establishment of NOELs has been done primarily to develop human health guidelines. Animal testing is reported in the section on human health. Data do not exist for groups of animals other than mammals.

Effects of Inert Ingredients

A full discussion of the effects of inert ingredients is presented in the human health risk assessment summary. Kerosene is the only inert ingredient of toxicological concern in herbicides used in the Southern Region.

Acute Effects

The Environmental Protection Agency has published a standard for ecological risk assessment (EPA 1986a). Standards from this publication are used in subsequent discussion.

The EPA standard for evaluating risk from herbicides and other chemicals to terrestrial wildlife is the comparison of actual dosage with the LD_{50} (the amount of chemical which kills [Lethal Dose] one-half [50 percent] of the test animal population in an acute toxicity test). If the probable dose is less than one-fifth the LD_{50}, it is considered to pose an acceptable level of risk for terrestrial wildlife. Any dose greater than one-fifth of the LD_{50} is considered to pose unacceptable risk for terrestrial animals (EPA 1936a).

The wildlife risk assessment presents the full evaluation of wildlife risk from herbicides applied at normal and extreme rates. Comparison of LD_{50} values with projected dose is presented in tables 8-4 through 8-14 of appendix A. A broad spectrum of animals is evaluated in the analysis; birds (common flicker, bobwhite quail, eastern bluebird, belted kingfisher, American kestrel, and red-cockaded woodpecker), mammals (southern short tailed shrew, red bat, eastern grey squirrel, meadow vole, eastern cottontail, white tailed deer, cotton rat, eastern red fox, black bear, river otter, and bobcat), amphibian (woodhouse toad), reptiles (eastern box turtle, hognose snake, and gopher tortoise), and domestic animals (cow, chicken, and dog). Scientific names are in table 8-35 of appendix A.

Typical Scenario

Results presented in tables 8-4 through 8-14 of appendix A show that all 11 of the herbicides and 3 additives applied at typical rates pose less risk than allowed under the EPA standard for wildlife and aquatic animals not listed as threatened or endangered.

Maximum Scenario

Results of modeling extreme rates are mixed. Dicamba, diesel oil, fosamine, glyphosate, imazapyr, kerosene, picloram, and sulfometuron methyl pose less risk than allowed by the EPA standard for all animals evaluated. Limonene also posed a lower risk than allowed, but data are unavailable to evaluate its effects on birds, reptiles, and amphibians. Dosage to several mammals is greater than allowable for hexazinone, tebuthiuron, and triclopyr; 2,4-DP showed greater than acceptable exposure for several birds and mammals; and 2,4-D showed unacceptable doses for some species in each of the terrestrial animal groups.

In summary, risk is at a low ("no risk") level, according to EPA standards for terrestrial animals, for all wildlife when typical application rates of herbicides are used. Exceeding typical rates, times, or any other consideration which increases dose can cause a slight to severe level of risk. Several of the herbicides evaluated had low ("no risk") levels of risk at the maximum rate of application, however, several did not.

Chronic and Cumulative Effects

Long-term studies have been performed on mammals to develop information for human health analyses (appendix A). These studies are given in the human health section. Studies evaluating oncogenic or mutagenic potential of these chemicals on other animals (birds, reptiles, or amphibians) are not currently available. Chronic effects are highly improbable since it is unlikely that terrestrial animals would be exposed more than once in a lifetime from Forest Service activities. Where Forest Service lands border treated private lands, exposure could be more frequent, but still are unlikely to approach levels which could cause chronic health effects in wildlife.

b. Effects on Habitat

Herbicides have an indirect effect on wildlife by altering vegetation species composition and structure. Depending on the herbicide applied, application rate and method, and vegetation affected, treatments can be detrimental to some wildlife species and beneficial to others. Herbicide effects on wildlife can include an increase in snag availability, or a reduction or increase in hard-mast production, soft mast production, ground vegetation (forbs, grasses), and foliage height diversity (layers of vegetation present within a stand).

Habitat Alteration From Site Preparation

To prepare a site for regeneration, herbicides may be applied alone or in combination with prescribed fire or mechanical treatment. Site preparation may be accomplished by broadcast application or by treating individual stems by injection, thinline, or foliar spray application of herbicides. Sites prepared by herbicide without mechanical treatment support a greater diversity and abundance of bird populations (Darden 1980) because of downed and standing woody material.

When herbicides are applied in bands rather than broadcast over an entire area, deer forage production is slightly higher the first year (Blake, Hurst, and Thomas 1987). Site preparation by herbicides alone results in numerous snags which provide perching sites for raptors (hawks and owls) and potential nest sites and foraging habitat for cavity-nesting and insect-feeding birds. This habitat results in an overall increase of bird diversity in treated clearcuts (Dickson, Connor, and Williamson 1983; Warren, Hurst, and Darden 1984). Removal of shading vegetation may adversely affect reptile and amphibian species, but fallen snags eventually create cover for amphibians and sunning sites for reptiles.

Herbicides used with fire usually result in a stand with sparse ground cover at first. Mourning doves and small mammals such as cotton rats (Sigmodon hispidus) find early successional stages attractive (McComb and Hurst 1987; Perkins 1973). Production of preferred deer forage can increase for several years following initial reduction after treatment with herbicides such as 2,4-D (Hurst and Warren 1981). Herbicides such as glyphosate reduce grass and herbaceous species the year following treatment but production recovers during the second growing season (Copeland and Hurst 1986). DeFazio, Stone, and Warren (1988) found that site preparation by broadcasting tebuthiuron pellets followed by burning caused some reduction in woody deer browse but also caused increases in grass, sedge, and forb forage. Their results varied among areas studied and did not indicate that overall impacts on deer were significant but led them to conclude that "... an application rate greater than or equal to 3.1 kg a.i./ha may be inappropriate when deer habitat is an important consideration."

Habitat Alteration From Pine Release

Treatment of pine stands at 3-6 years of age to control hardwood stems tends to encourage growth of grass, forbs, and vines. This improves conditions for ground-feeding birds, white-tailed deer, and wild turkey by increasing seeds and forage (Hurst and Warren 1986). When applied by broadcast methods, however, these treatments reduce the number of soft-mast producers such as vacciniums and dogwood, which are used by many species of wildlife. Herbicide applications which result in top-kill of hardwoods tend to reduce mast production by relegating many mast-producers to the midstory of the future stand. Root-kill applications cause a more serious reduction by eliminating certain mast-producers altogether. This can have a detrimental effect on deer, turkey, gray squirrels, and many species of songbirds.

Release by selective methods such as spot-around or foliar spray makes it possible to leave individual stems or clumps of mast-producing or other desirable hardwoods. Studies of stands treated with 2,4-D show that retaining even small scattered patches of brush helps maintain bird density and abundance after treatment (Morrison and Meslow 1984b).

The use of herbicides such as glyphosate, which control grasses and herbaceous vegetation, results in temporary reduction in forage. But species composition, total biomass, and forage production are usually similar to untreated areas by the second growing season (McComb and Hurst 1987).

Accelerated growth of pine which results from successful release treatment may benefit some wildlife species because it allows pine stands to be burned and thinned sooner (Owen 1984). Broadcast application of imazapyr increases production of forbs and vines, including important deer forage species like blackberry and dewberry, while reducing woody browse (Hurst 1987).

Habitat Alteration From Stand Improvement

When used for timber stand improvement (TSI), injection of competing hardwood stems in mixed pine-hardwood stands reduces hard-and soft-mast production unless selected stems are left. This reduction harms species such as white-tailed deer, gray squirrel, and many songbirds. Increased snag availability, however, benefits cavity nesters and small mammals that will use openings created in the stand (McComb and Rumsey 1982). Snags created by herbicides tend to remain standing for a shorter time than those created by other means such as girdling (Conner, Kroll, and Kulhavey 1983). Shrub fruit-producers and vines such as honeysuckle increase, benefiting white-tailed deer and many birds. Increased pine seed production benefits fox squirrels and other species.

In the short run and possibly in the long run, bird abundance and diversity increase when some overstory in upland hardwood stands is removed by broadcasting picloram or 2,4-D. The increase is probably due to the resulting increase in diversity of vegetation layers (McComb and Rumsey 1983; Morrison and Meslow 1984a, 1984b.) Habitat for foliage-gleaning birds, however, may be reduced.

Because wild grapes are an important food source for at least 80 bird species and many other species of wildlife, Smith (1984) recommends that large clumps (arbors) of wild grapes be retained when grapevine control is conducted in timber stands. Although treatment with 2,4-D will kill grapes, seeds in the duff layer will germinate and provide new stems after treatment.

Applied selectively for wildlife stand improvement (WSI), herbicides release mast-producing hardwoods and increase mast production for deer, turkey, squirrel, bear, and other species. When hardwood midstories are reduced, production of deer forage increases, especially when prescribed fire is also applied (Blair and Feduccia 1977). Spray application of 2,4-D can be effective in top-killing mountain maple and inducing a regrowth of sprouts which are valuable as deer browse. 2,4-D may also be used to improve ruffed grouse habitat by creating openings in dense aspen stands (Schacht and Hansen 1963).

Habitat Alteration From Rights-of-Way (ROW), Balds, and Openings Maintenance

Wildlife openings and rights-of-way corridors provide early successional stage habitat. Such habitats vary from grass/forb to brush cover depending upon how they are maintained. They also provide transitional zones or "edge," which may increase species diversity. When ROWs transect and fragment large intermediate or mature hardwood stands, some bird species which need large stands to reduce nest parasitism and predation may decline. Although little research exists, naturally created edges (as by wildfire) may reduce this effect compared to abrupt artificial edges (Reese and Ratti, in press).

Use of herbicides in wildlife openings maintenance is usually directed at control of persistent non-native grasses such as fescue or control of encroaching hardwood brush. This treatment helps establish native or other grasses, legumes, and forbs. Broadcast application of liquid hexazinone has been used successfully to create wildlife openings for turkey in the Ozark Mountains (Nelson, Hartman, and Leeds [1988]).

Herbicides on ROW corridors may be broadcast or selective. Repeated treatments may result in a low-shrub community which is stable and resistant to invasion by tree species. Such a community develops more rapidly and without the initial loss of brush cover when selective spraying is used (Eaton and Gates 1981). It usually has a substantial soft-mast producing component, and is more beneficial to some small mammals and deer than a grass-forb community (Ladino and Gates 1981). Arner (Mississippi State University, personal communication), however, found that this type of treatment in Mississippi tended to favor sumacs (*Rhus* spp.) rather than fruit-producers such as vacciniums which are more valuable to many species of wildlife. When shrub cover is patchy and varying in height, a greater diversity of bird species will occur (Kroodsma 1982).

Selective herbicide application to brush or trees that reach a predetermined height results in habitat favorable for white-tailed deer (Bramble, Byrnes, and Hutnick 1985) and some songbirds (Kroodsma 1982; Myers and Provost 1981).

Herbicides are used alone or in conjunction with other treatments to reduce encroachment of woody brush on mountain balds. Maintenance of open conditions may benefit raptors through improved prey availability (Sander 1980).

2. Effects of Prescribed Fire

a. Direct Effects

Direct mortality from prescribed fire has a negligible effect upon animal populations (Lyon and others 1978). Less mobile species such as shedding diamondback rattlesnakes (*Crotalus adamanteus*) (Means and Campbell 1981) or frogs (Vogl 1973) may occasionally be killed. Most observers, however, indicate that this is rare (Komarek 1969) and that mortality is not normally associated with slow-moving prescribed fires. Furthermore, even fires started by an aerial ignition pattern which results in numerous spot fires rather than linear flame fronts do not result in significant vertebrate mortality (Folk and Bales 1982). A notable exception is the Eastern glass lizard (*Ophisaurus* *ventrali*) which may be killed in considerable numbers when prescribed burns are conducted (Means and Campbell 1981).

Larger animals such as white-tailed deer usually move calmly away from advancing fires. There is no evidence that wildlife is harmed by smoke. Raptors, bobwhite quail, turkey, and insectivorous birds are often attracted to recently burned or actively burning and smoking areas (Komarek 1969; Landers 1987; Lyon and others 1978; Stoddard 1963). When burns are conducted during the nesting season, some eggs and young of ground-nesting species are destroyed.

b. Effects on Habitat

Prescribed burning affects different species in different ways. Some effects on wildlife habitats include an increase in the amount, availability, and palatability of forage; changes in production of soft mast; changes in invertebrate populations; and the creation and destruction of snags (Van Lear and Johnson 1983). Many animals have adapted to habitats that are subjected to recurring fires. Some, like bobwhite quail, depend upon fire to maintain their environment (Landers 1987).

Without periodic prescribed burning in most southern pine types, increased fuels increase the occurrence of intense and unplanned wildfires. Habitat alteration from these fires is often severe since overstory vegetation, as well as smaller woody stems, may be destroyed.

Prescribed fire has not traditionally been used as a wildlife management tool in hardwood and mixed hardwood-pine stands because it may introduce defect or reduce the vigor of hardwood trees. However, cool burns may be appropriate for improving turkey habitat or regenerating scrub oak species such as bear oak, a prolific mast-producer.

A major research need in the area of prescribed fire is the relationship of prescribed fire effects to fire behavior. In other words, how do intensity, duration, and season of burning affect various wildlife species? Data related to effects of burning on many species in the South, particularly songbirds, reptiles, and amphibians, are meager.

Habitat Alteration From Site Preparation

When regenerating southern pines, prescribed fire is used alone or with herbicide or mechanical treatments. Depending upon intensity, broadcast burns may remove very little to virtually all live vegetation and residue. This condition is temporary, however, because roots, bulbs, and dormant seeds are stimulated by fire and soon sprout. Conditions soon become favorable to ground feeders like meadowlarks (Sturnella magna). Deer forage and production of seeds used by birds such as quail increase dramatically, peaking the first or second season after burning (Stransky and Halls 1979b; Warren 1981.) After 2 or 3 years, conditions improve for species such as cottontail rabbits and cotton rats. Fruits, important to species such as black bear, decrease initially but soon increase (Hamilton 1981).

Site-preparation burning of low-quality upland hardwood stands may improve deer browse availability and make browse available for a longer period following timber harvest (Waldrop, Buckner, and Muncy 1985). However, available browse was not used except near the edge of clearcuts. But when Appalachian hardwood clearcuts are burned following timber harvest, logging slash and debris used by hairy and downy woodpeckers is destroyed (Conner and Crawford 1974).

Mast production in scrub bear oak stands begins to decline around age 15. Prescribed burning regenerates bear oak stands, which will begin to produce mast within 3 years of burning (personal communication, John Coleman, U. S. Forest Service).

Habitat Alteration From Stand Improvement

Prescribed underburns are carried out in pine and pine-hardwood stands ranging from saplings to mature stands. Whether they are used to improve conditions for wildlife, maintain, reduce hazardous fuels, or control competing vegetation, their effects on wildlife are similar. Effects vary, however, according to season, intensity, and frequency of burns.

Burning has long been used as a tool in the Southern pine types to improve white-tailed deer habitat. Research indicates that nutrient content (particularly protein and phosphorous) and palatability of deer food increase temporarily after burning. But effects on deer browse from wildlife or fuel-reduction burns applied at 3-5 year intervals may be small and short-lived (Wood 1988). Also, fruit yields of understory shrubs decrease immediately, then increase to levels higher than before burning and decline gradually. Optimum fruit production probably occurs when pine stands are burned every three years (Johnson and Landers 1978). In addition, deer browse decreases initially, but increases rapidly for several years afterward (Blair and Enghart 1976; Hurst and Warren 1982; Stransky and Harlow 1981). Browse after burning generally grows out of the reach of deer after 4-5 years (Landers 1987). Repeated burns, particularly during the growing season, may reduce the amount of woody vines such as honeysuckle, an important deer food (Landers 1987). Consequently, protecting some areas from burning is important.

Periodic dormant-season burning of scattered areas probably benefits black bear because it increases production of some fruits (Hamilton 1981). Prescribed burning benefits most fur-bearers because fire increases prey abundance and availability. Burns also increase production of fruits such as blackberry and blueberry. Production of important foods such as persimmon and grapes, however, may decline (Johnson and Landers 1978; Miller and Speake 1978).

Many small mammals need the early successional forest stages created or maintained by fire. Long-term studies indicate that rodents such as the eastern harvest mouse (Reithrodontomys humulis) and hispid cotton rat, which feed on seeds and grass, usually increase after prescribed fire. Insectivorous mammals like short-tailed shrews tend to decrease (Landers 1987). Other (short-term) studies have shown immediate reductions of mice and rats accompanied by increases of shrews (Fala 1975; Landers 1987). When fire is used to control hardwoods in pine stands, it generally has a negative impact on squirrels since it reduces future production of acorns. Habitat will generally remain suitable for squirrels as long as scattered patches of mast-producing hardwoods remain interspersed in pine stands (Landers 1987). Prescribed fire, particularly patchy burning done annually or biennially, appears to be beneficial to rabbits (Hill 1981).

Annual or biennial dormant-season burning for quail is a management tool in the South. Most managers agree that fire should be excluded from some areas to provide 2-3 year old roughs necessary for nesting cover and soft-mast production (Hurst 1981; Landers 1981; McRae and others 1979). Burning for management of wild turkey is also common. Although it is generally conducted on a longer (3-5 year) rotation than burns for quail management, shorter burning retations may be more appropriate for maintaining brood range habitat (James Pack, West Virginia Department of Natural Resources, personal communications). Benefits include increases in legumes, reduction in external parasites, maintenance of brood habitat for poults, and increases in the arthropod food supply. Early growing season burns or burning less frequently than every 5 years may reduce lespedezas and other legumes important as food sources for quail and turkey (Lewis and Harshbarger 1976, 1986; Speake 1966). Decline in hard-mast, important for turkey, squirrels, and many other species, may result from repeated burning which also can reduce the overall hardwood component of a stand.

Prescribed burning may be used in thinned hardwood stands to provide turkey brood range (Pack and others 1980). Rogers (1986) noted that burned ridgetops and bottoms received more use by poults than steep slopes but that profuse growth resulting from prescribed burns may hinder poult movement.

Growing-season burns are sometimes used in pole-timber hardwood stands to improve habitat conditions for ruffed grouse.

Low-intensity dormant-season burns may be used in mature pine-hardwood stands to improve deer-browse conditions without damaging large hardwoods or altering other habitat variables sufficiently to cause changes in small-mammal populations (Sanders, Van Lear, and Guynn 1987).

Burning has effects on other bird species as well. Prescribed fires may eliminate standing dead trees that provide cavity nest sites. However, fires also kill trees, thus providing sites for new cavities (Conner 1981). According to Dickson (1981), burning increases early successional species such as Bachman's sparrow (Aimophila aestivalis) and birds such as pine warblers (Dendroica pinus) which inhabit intermediate to mature pine stands. Although breeding bird density increases with increasing shrub density following the elimination of fire from hardwood stands, populations of prothonotary warbler, robin, and red-headed woodpecker may decline since these species prefer open, park-like stands (Zeedyk and Evans 1975). When variations in fire behavior result in patchy vegetation, bird diversity tends to increase (Landers 1987).

Periodic burning helps to temporarily provide open conditions. Such conditions make hunting of small mammals and birds by hawks easier, and tend to attract many species of predatory birds. Red-tailed hawks (Buteo jamaicensis), kestrels (Falco sparverius), and loggerhead shrikes (Lanius ludovicianus) often feed in freshly burned areas (Komarek 1969). Ruffed grouse and ground-feeding song birds may be attracted as well (Euler and Thompson 1978).

Little research exists on fire effects on reptiles and amphibians in the South.

Habitat Alteration From ROW, Balds, and Openings Maintenance

Prescribed fire is not commonly used in the Appalachian Mountains as a means of managing vegetation in wildlife openings and ROWs. Limited research indicates that compared to mechanical or herbicide treatments, dormant-season burning produces more arthropods and insects for birds to feed on (Hurst 1970) and may produce more legumes and other plants used by birds like quail (Huntley and Arner 1981). When fire is used to maintain mountain balds it improves hunting conditions for raptors (Sander 1980) and does not seem to affect small-mammal populations (Robinson 1981).

3. Effects of Mechanical Methods

a. Direct Effects

Mechanical methods occasionally cause direct mortality of adult animals or result in destruction of eggs or young. Normally, vertebrate species are able to flee in advance of equipment and escape harm, although some reptiles and amphibians may be killed. Mowing, chopping, shearing, raking, disking, and other mechanical tools cause some direct mortality to invertebrates, but, because of large populations and high reproductive rates, populations are not hurt. Destruction of eggs and young depends upon season of treatment and can occur when equipment is used during the nesting season.

Disturbance caused by equipment used for site preparation may result in abandonment of young or nests. With larger vertebrates such as deer or rabbits, such abandonment is normally temporary. Ground-nesting birds may permanently abandon nests if disturbance occurs soon after nesting begins but will tolerate greater disturbance when eggs are close to hatching. Although most ground-nesters will renest, survival rates for young from late-season nesting attempts are generally lower.

b. Effects On Habitat

Specific research on the effects of mechanical treatments on many species is scarce. Fortunately, since data regarding the effects of mechanical treatments on vegetation structure and species composition are available, conclusions regarding effects on wildlife can be made. In some ways, effects are similar to those resulting from herbicide or fire, but vary depending on the degree to which root stocks are destroyed.

Habitat Alteration From Site Preparation

As with prescribed burning, most mechanical site preparation treatments increase the number of plant species and amount of herbaceous ground cover as compared with uncut, mature forest stands. More intensive mechanical methods, however, such as raking, reduce the number of woody fruit-producers (Stransky and Halls 1980; Stransky and Roese 1984; Swindel, Conde, and Smith 1984).

Small seed-eating mammals that use early successional habitat benefit more from mechanical site preparation if windrows, scattered brush cover, and downed logs are not removed (as by burning) (Buckner and others 1979). Rabbits and many reptiles and amphibians benefit as well. Short-term (up to age 5) increases in deer forage following mechanical treatments can be dramatic. Chopping, which doe not destroy plant root systems, generally results in higher browse production than more intensive mechanical methods (Stransky and Halls 1979b).

When intensive mechanical treatments such as shear, rake, and windrow are used in conjunction with burning, soft-mast species such as blackberry and pokeweed soon invade (Campo and Hurst 1980). These open sites attract ground feeders such as mourning doves the first year following treatment. As more cover becomes available (2-3 years), species such a bobwhite quail utilize the site. Turkey use the areas for nesting cover as well. Retaining windrows also increases use by species such as house wrens (Troglodytes aedon) (Rowse and Marion 1981). With all site preparation methods, retention of snags greatly increases use by cavity nesters and raptors.

Based on limited research, it appears that intensive treatments which remove debris reduce the numbers of reptiles and amphibians. However, intensive treatments may provide habitat for tree-dwelling reptiles sooner than less-intensive treatments. A patchy distribution of habitats allows for more rapid recolonization after treatment (Enge and Marion 1985).

Habitat Alteration From Other Stand Treatments

Use of mechanical treatments for other purposes is minor. Effects are similar to those discussed in the preceding section. Chopping for pine release helps species such as deer by opening strips in dense stands, thus increasing production of forbs and legumes.

Habitat Alteration From ROW, Balds, and Openings Maintenance

Mowing is the primary mechanical method for maintaining ROWs, wildlife openings, and developed recreation sites. It may also be used to manage mountain balds. Mowing maintains a grassy groundcover which can provide nesting and bugging habitat for turkey, and cover for several species of rodents. Frequent mowing, however, reduces cover for species like cotton rats and ground-nesting birds (Schmidly and Wilkins 1977). Less-frequent mowing and strip mowing benefits most wildlife species found in ROWs because such practices leave islands of cover for nesting and escape.

Healy and Nenno (1983) recommend, that for turkey brood range, wildlife openings should be maintained by the simplest method possible. Late growing-season mowing on a 1-2 year rotation should be adequate to maintain the necessary grass-forb cover. They suggest that since mowing appears to reduce both numbers of arthropods and seed production, growing-season mowing should be delayed until at least one month after the peak of turkey hatching.

Light disking is sometimes used to break-up grass cover and encourage native legumes, which are an important food for ground-feeders like quail. Urban (1975) reported that soil-disturbance (strip-disking) in conjunction with prescribed burning results in preferred cottontail rabbit food in wildlife openings. His data indicated that burning alone did not produce the desired response.

4. Effects of Manual Methods

It is unlikely that manual methods cause any direct mortality except when removal of brush or trees destroys nests or young. Human disturbance may cause temporary or permanent abandonment of young or nests. Losses are minor and can be reduced if workers resist the temptation to "rescue" apparently orphaned animals. Normally, disturbance is short-lived, as workers move on to untreated areas and animals return. Effects on habitat are similar to those described for mechanical techniques that do not disturb the soil.

Selective hand-cutting of trees underneath overhead wires and cutting of tall trees along ROW edges helps maintain bird species diversity better than treatment by aerial broadcast herbicide or periodic mowing (Bramble, Byrnes, and Schuler 1986).

Grapevine density can be seriously reduced when hand-cutting is done in mature stands that are not harvested within 4 years. Although vines resprout after treatment, shading overstory vegetation results in die-back within a few years. Consequently, large clumps (arbors) of grapevine should be protected from treatment (Smith 1984).

5. Effects of Biological Methods

Grazing of cattle, sheep, and horses is used to manage mountain bald vegetation. Insignificant direct mortality occurs when livestock trample nests or the young of ground-nesting birds. Also, there is a potential for transmission of diseases such as epizootic hemorrhagic disease (which affects deer) from livestock to wildlife populations.

Heavy year-round grazing reduces quality of habitat for many wildlife species. Research indicates, however, that light to moderate cattle grazing generally has little adverse impact on seed-producing plants important to ground feeders (Lewis and Harshbarger 1986). Short periods of intense grazing tend to reduce grasses and increase forbs eaten by deer and turkey (Moore and Terry 1979).

E. THREATENED, ENDANGERED, PROPOSED, AND SENSITIVE SPECIES

Introduction

The generalizations regarding effects of vegetation management on wildlife presented in section D also apply to species listed as threatened, endangered, proposed, and sensitive. Procedures required in chapter II, including site-specific biological evaluation and environmental analysis, are designed to ensure that these species are protected when vegetation management projects (including those designed to benefit the species) take place. Forest inventories, Forest Land and Resource Management Plans, recovery plans, and Forest Service Handbook chapters are also important.

For some other species, particularly those adapted to a disturbance-related environment, use of vegetation management techniques such as prescribed burning to mimic natural disturbances is essential for continued species viability. The red-cockaded woodpecker, for example, requires open pine stands without a hardwood midstory. Prescribed fire on a 2-3 year rotation will maintain habitat that is already suitable. Herbicide, manual or mechanical treatments, or growing season burns are required to control hardwood stems larger than 2 inches and restore habitat suitability to colony sites with encroaching hardwoods (FSH 2609.23R R8 AMEND 13).

As discussed in chapter II, recovery plans and Forest Service Handbook chapters have been prepared for several threatened, endangered, and proposed species. With some of these species, factors such as poaching or loss of critical habitat outside of national forests combine to hinder species recovery. Recovery plans and handbook chapters consider these factors when establishing guidelines for Forest Service practices which may affect threatened, endangered, and proposed species.

There is a need for recovery plans and handbook chapters to be prepared for each of these species in the Southern Region and for each national forest to prepare guidelines for protecting and managing sensitive species occurring on the forests.

General effects of vegetation management methods on threatened, endangered, proposed, and sensitive species are presented in tables D-1 through D-6 in appendix D (the biological evaluation for this document). Measures to mitigate these effects are presented in appendix D and in chapter II.

1. Effects of Herbicides

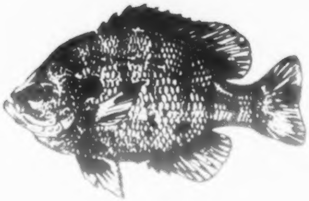
Terrestrial Species

The EPA standard for chemical exposure considers a dose of less than 1/10 LD50 as not presenting a significant risk for a threatened or endangered terrestrial species. Based on toxicity data and exposure predictions made in the risk assesment, most of the herbicides analysed do not present a significant risk to any threatened, endangered, or proposed species when applied at typical rates. There is a probability of significant risk (dose exceeds 1/10 LD50), however, from 2,4-D, 2,4-DP, and triclopyr to the Indiana bat, gray bat, and Virginia big-eared bat. 2,4-D also presents a significant risk to the following sensitive species: star-nosed mole, old-field mouse, southeastern shrew, longtail shrew, southern water shrew, southern pygmy shrew, red-backed vole, keen's myotis, easter small-footed bat, and rafinesque's big-eared bat.

If applied at maximum rates, 2,4-D, 2,4-DP, dicamba, hexazinone, tebuthiuron, and triclopyr present a significant risk to most of the threatened, endangered, and proposed species listed in tables F-1 and F-2 and most of the sensitive species listed in tables F-3 and F-4.

Low toxicities, low risk of exposure, and mitigation measures (detailed in chapter II) governing the use and handling of herbicides, combined with requirements for site-specific inventories and environmental analyses, make the probability of direct toxic effects on threatened, endangered, proposed, or sensitive animals low. Key mitigation measures include a prohibition on application at maximum rates and limitations on use of herbicides identified in this chapter as posing significant risk.

Aquatic Species



The EPA standard for theatened, endangered, or proposed aquatic animals identifies an exposure of greater than 1/20 LC50 as presenting a significant risk. Based on predictions regarding exposure of the representative species analysed in the risk assessment to two accidental spill scenarios, 2,4-D (ester) and 2,4-DP present a significant risk to the following mussels: pearly birdwing, pearly dromedary, James River spiny, green-blossom pearly, tan riffle-shell spiny, yellow blossom pearly, fin-rayed pigtoe pearly, shiny pigtoe pearly, and Appalachian monkeyface pearly, and to the noonday snail. The slender chub, spotfin chub, smoky madtom, yellowfin madtom, conasauga log perch, and amber darter face a risk from an accidental spill of 2,4-D (ester), 2,4-DP, diesel, glyphosate (Roundup), kerosene, limonene, triclopyr (ester), and sulfometuron methyl.

An accidental spill of these chemicals poses a significant risk to most of the aquatic animals listed in table F-3 as well.

Mitigating measures in chapter II regarding the transportation, handling, and application of herbicides are designed to make the likelihood of such an accidental spill very small.

Plant Species

Threatened, endangered, proposed, and sensitive plant species can be extremely sensitive to the effects of herbicides and direct treatment can destroy a local population. If the population is isolated, as many are, there may be no means for natural reestablishment. Response varies depending on several factors. Dicamba, for instance, might kill Virginia roundleaf birch, a woody plant, but have little effect on a herbaceous species like mountain golden heather. Stem injection of hardwoods with picloram would not threaten a nearby population of Oglethorpe oak, whereas foliar spraying might. Although risk is lower when a herbicide has low efficacy for controlling a particular plant species, all of the herbicides analyzed are toxic to any plant when applied at sufficient rates, and are considered to pose a significant risk to all threatened, endangered, proposed, and sensitive plants occurring in the Appalachian mountains when they are applied by broadcast methods. This risk may be mitigated by conducting site-specific inventories and environmental analyses and by carefully selecting chemical, rate, method and season of application (see chapter II).

Sensitive plants may benefit, however, when herbicides are used to control competing vegetation, providing that non-target species are not inadvertently damaged by the application.

2. Effects of Prescribed Fire

Some plant species, such as wretched sedge, are harmed and should be protected from fire. Other species, however, are associated with habitats that are created or maintained by fire. For example, without periodic burning, habitats of the red-cockaded woodpecker and mountain golden heather becomes unsuitable. Past exclusion of fire from these species' habitat has hastened their decline. Season and intensity of burning, however, must be controlled to prevent habitat damage.

3. Effects of Mechanical Methods

Most threatened, endangered, or proposed plant species are harmed by mechanical treatments, particularly those techniques that disturb the soil. Some plants may benefit by release from competing vegetation or be stimulated to reproduce.

As with burning, mechanical treatments may either harm or benefit these species.

4. Effects of Manual Methods

Manual treatments are less likely than mechanical treatments to be harmful to threatened, endangered, proposed, or sensitive plants since they do not disturb soil or root systems. Most woody species will respond by resprouting, but others may be killed if treated directly.

5. Effects of Biological Methods

Some plants may respond favorably to light grazing. Others, such as Biltmore sedge, should be protected from foraging animals.

As with other species, heavy, continuous grazing damages habitat. Short-duration grazing, however, may benefit some species by causing vegetation response similar to that caused by wild herbivores (American bison) which formerly occupied their range.

F. SOIL

Introduction

Productivity, a site's ability to grow vegetation over time, depends on physical, chemical, and biological qualities of the soil. Productive soils have loose and porous structure, ample reserves of organic matter and nutrients, and balanced populations of small organisms.

Sensitivity to disturbance varies with soil fertility. Poor soils such as severely eroded soils are infertile (low in organic matter and nutrients) and highly sensitive. Fair soils such as shallow inceptisols and partly eroded soils are intermediate in fertility and moderately sensitive. Good soils are fertile and slightly sensitive (table IV-9).

Table IV-9.--Distribution of soil fertility classes in the various landtypes*

Landtype	--------Percent of Landtype-------		
	Poor	Fair	Good
BLUE RIDGE			
Narrow Ridge	-	3	97
Blue Ridge Mtns.	-	3	97
Unaka Mtns	-	4	96
RIDGE AND VALLEY			
Folded Highlands	-	3	97
Faulted Lowlands	2	5	93
APPALACHIAN PLATEAUS			
Cumberland Mtns.	-	2	98
Kentucky Basin	2	3	95
Table Plateaus	-	1	99

*See Figure IV-4, section G (Water) for map of landtypes

1. Effects of Prescribed Fire

Prescribed fire has both favorable and adverse effects on soil. Favorable effects are temporarily enhanced nutrient availability and phosphorus cycling and reduced soil acidity (Christensen 1976; McKee 1982). Adverse effects are caused by soil heating, soil erosion, and nutrient leaching. Soil heating can kill soil biota, alter soil structure, consume organic matter, and remove site nutrients during the burn. Soil erosion and nutrient leaching occur during later rainstorms and cause smaller nutrient losses.

There are three main types of prescribed fire: (1) slash burns in harvested stands; (2) underburns beneath stands; and (3) grass burns on mountaintop balds. Effects on soil vary with type of burn.

Slash burns are a site preparation tool used to regenerate harvested stands. They typically occur every 50-90 years in pine stands and every 60-120 years in hardwood stands. Risk of adverse effects depends mostly on fire severity, which is defined by ground condition after the burn (Wells and others

1979), and differs from fire intensity. An intense slash burn done when duff, soil, and larger fuels are moist will seldom be severe (appendix E).

Underburns occur every 3-9 years and are generally light to moderate in severity. Adverse effects from a single burn are minimal. Risk of adverse effects from repeated burns depends mostly on their frequency and season of use.

Grass burns occur every 2-4 years and are light to moderate in severity. Risk of adverse effects depend mostly on frequency of burn.

Soil Heating

Light slash burns scorch the litter and duff on most of the area. Soil heating has little effect on soil biota, structure, or organic matter. Less than 150 lb/ac of nitrogen is released as gas from slash, litter, and duff. Effects on other soil nutrients (phosphorus, potassium, calcium, magnesium) are favorable (appendix B).

Moderate slash burns char and partly consume the litter and duff on most of the area. Soil biota are reduced but recover quickly. Soil structure is not affected. Much litter and duff may be consumed, but soil organic matter is little affected. Between 300 and 350 lb/ac of nitrogen may be released as gas from slash, litter, duff, and topsoil. Other soil nutrients are little affected (appendix B).

Severe slash burns consume all litter and duff and alter the color and structure of mineral soil on most of the area. Destruction of soil biota sterilizes the site and full recovery takes years. Soil porosity, infiltration, and moisture capacity are reduced. About 90 percent of litter and duff and 50 percent of topsoil organic matter are often consumed. Between 650 and 850 lb/ac of nitrogen may be released as gas from slash, litter, duff, and topsoil. Large amounts of phosphorus may also be lost (appendix B).

Underburns more frequent than every 3 years do not affect soil biota, but litter-duff biota are reduced and do not fully recover before the next burn. Loss of organic matter exceeds 10 percent. Nitrogen loss may be up to 160 lb/ac for dormant season burns and 600 lb/ac for growing season burns. Annual underburns also impair soil porosity and infiltration (appendix B).

Underburns every 3-4 years allow litter-duff biota to fully recover between burns. Soil physical properties are not affected. Loss of organic matter is about 5 percent. Nitrogen loss may be 100-150 lb/ac for dormant season burns and 400-450 lb/ac for growing season burns (appendix B).

Underburns every 5 years or more have little effect on biot and soil structure. Organic matter increases by about 5 percent. Nitrogen loss may average 90 lb/ac for dormant season burns and 240 lb/ac for growing season burns (appendix B).

In grassy balds, most biomass and nutrients are below ground. Nutrient loss is less harmful than in forests. Annual grass burns, however, pose high risk to soil productivity via reduced litter biota, impaired soil porosity and infiltration, and reduced organic matter. Ris is minimal for cycles of 3 years or more (appendix B).

Soil Erosion

Effects of prescribed fire on soil erosion depend on fire severity. Severe slash burns can cause serious erosion, because they expose mineral soil on much of the area and recovery may take 3 years. Moderate burns cause minor erosion, because they expose soil on less than 20 percent o the area and recovery usually takes 1 year. Light burns cause no erosion because they expose almost no soil (Dissmeyer and Stump 1978). Underburns and grass burns are usually light to moderate, so their effect on erosion is generally negligible (appendix B).

Potential erosion is estimated by the Universal Soil Loss Equation (USLE). USLE computes potential erosion to increase with greater rainfall energy, soil erodibility, an slope length and steepness; and to decrease with greater ground cover provided by vegetation, litter, rock, and fine roots (Dissmeyer and Foster 1984). Average values of rainfall, soil, and slope factors for the various landtypes (Dissmeyer and Stump 1978) are shown in table IV-10.

Table IV-10.--Average values of USLE factors for the landtypes

			USLE Factors		
Landtype	Slope Steepness (Percent)	Slope Length (Feet)	Rainfall	Soil Erodibility	Slope/ Length
BLUE RIDGE					
Narrow Ridge	35	100	160	0.24	10.26
Blue Ridge Mtns.	40	100	250	0.24	12.70
Unaka Mtns.	40	100	200	0.24	12.70
RIDGE AND VALLEY					
Folded Highlands	30	120	150	0.28	8.75
Faulted Lowlands	25	120	320	0.28	6.48
APPALACHIAN PLATEAUS					
Cumberland Mtns.	30	160	150	0.28	10.10
Kentucky Basin	25	160	200	0.28	7.49
Table Plateaus	15	110	320	0.28	2.70

Effects of fire on ground cover were estimated from many field observations in the South (Dissmeyer and Stump 1978) as modified by erosion research (Blackburn, Wood, and DeHaven 1986; Brender and Cooper 1968; Cushwa, Hopkins, and McGinnes 1971; Douglass and Van Lear 1983; Goebel, Brender, and Cooper 1967; Miller 1984; Ursic 1969, 1970). USLE's cover factor is estimated at 0.000 for light burns, 0.002 for moderate burns, and 0.015 for severe burns. Potential erosion in the various landtypes (appendix B) is shown in table IV-11.

Table IV-11.--Average potential erosion (tons per acre) for treatments by landtype

Landtype	Mod. Burns Herbicides	Chop/Shear Pile*	Rake*	Severe Burns	Disk*
BLUE RIDGE					
Narrow Ridge	0.79	0.47	0.79	5.91	3.18
Blue Ridge Mtns.	1.52	1.07	1.24	11.43	4.97
Unaka Mtns.	1.22	0.85	0.99	9.14	3.97
RIDGE AND VALLEY					
Folded Highlands	0.74	0.57	0.95	5.51	3.81
Faulted Lowlands	1.16	0.76	2.03	8.71	8.12
APPALACHIAN PLATEAUS					
Cumberland Mtns.	0.84	0.55	1.47	6.29	5.88
Kentucky Basin	0.85	0.65	1.10	6.36	4.41
Table Plateaus	0.48	0.39	1.95	3.63	7.80

*Erosion from mechanical tools would be greater if mitigation measures did not require contour treatments limited to average slopes of 10-25 percent for chop and 10 percent for rake and disk.

Nutrient Leaching

Leaching losses from prescribed fire depend on fire severity. Nitrogen is often mobilized in the topsoil after fire by infiltration and fixation. Some is leached through the soil and into streams. Losses of nitrogen may be 1 lb/ac for light burns, 3 lb/ac for moderate burns, and 20 lb/ac for severe burns. Losses of other, less mobile nutrients are negligible. Underburns do not cause significant leaching losses because nutrients are retained through uptake by unburned plants (appendix B).

Long-term Effects

Nitrogen budgets (table IV-12) show that timber harvest followed by light slash burns produces positive nitrogen budgets and allows long-term nitrogen buildup. Moderate burns produce neutral nitrogen budgets. Severe burns produce negative nitrogen budgets and cause long-term nitrogen depletion; losses over one timber rotation amount to 21 percent of site total in poor soils, 16 percent in fair soils, and 14 percent in good soils (appendix B).

Table IV-12.--Cumulative nitrogen budgets (lb/ac) for pine stands on 60-year rotatio

	Light Burns	Moderate Burns	Severe Burns	Piling	Raking
LOSSES					
Harvested Stems	140	140	140	140	140
Slash Removal	28	55	99	99	99
Litter Removal	100	200	360	200	360
Soil Heating*	-	60-105	220-385	-	-
Soil Displacement*	-	-	-	-	200-350
Soil Erosion#	-	6	46	4	5
Leaching	61	63	80	63	70
TOTAL	329	524-569	945-1110	506	874-1024
INPUTS					
Atmospheric	300	300	300	300	300
Plant Fixation	100	100	100	20	20
Other Fixation	200	200	200	180	180
TOTAL	600	600	600	500	500
NET BUDGET					
Poor Soils	+271	+76	-345	-6	-374
Fair Soils	+271	+55	-422	-6	-444
Good Soils	+271	+31	-510	-6	-524

*Nitrogen lost varies with soil nitrogen content.
#Erosion values used are average values for the Blue Ridge Mountains.

For dormant season underburns every 3-7 years, long-term nitrogen loss may be 3-5 percent of site total in fair and good soils and 6-8 percent in poor soils. Losses for growing season underburns every 5-7 years may be 7 percent in good soils, 8 percent in fair soils, and 13 percent in poor soils. Losses for growing season underburns every 3-4 years may be 12 percent in good soils, 15 percent in fair soils, and 22 percent in poor soils (appendix B).

Overall Risks

Long-term effects on nitrogen are combined with effects on soil biota, physical properties, and organic matter to judge overall risk to soil productivity. Risk of light slash burns is minimal on all soils. Risk of moderate slash burns is minimal on good and fair soils, and low on poor soils where they prevent long term soil recovery. Risk of severe slash burns is extreme on poor and fair soils, and high on good soils.

Risk to soil productivity from underburns depends on their frequency and season. For 5+ year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, while risk from growing season burns is low on good and fair soils and medium on poor soils. For 3-4 year underburns, risk from dormant season burns is minimal on good and fair soils and low on poor soils, where they prevent long-term soil recovery, while risk from growing season burns is medium on good and fair soils and extreme on poor soils. For 1-2 year underburns, risk from dormant season burns is medium on good soils, high on fair soils, and extreme on poor soils, while risk from growing season burns is extreme on all soils.

Mitigating Impacts

Severe burns are avoided by conducting slash burns so they do not consume all litter and duff and alter structure and color of mineral soil on more than 20 percent of the area. One way to achieve this result is to schedule slash burns one to three days after a soaking (0.5 inch or more) rain when soil, duff and large fuels are moist. In addition, poor soils can be protected by not burning any area with an average litter depth of less than 1/2 inch. For 3-4 year underburns, risk to soil productivity from growing season burns can be reduced to low on good and fair soils and high on poor soils by alternating them with dormant season burns. Mitigation measures required to protect soil from prescribed fire are in section II.E.2.a.

Data Gaps

Data are lacking on effects of severe slash burns on soil in the South. Underburns have been extensively studied, but studies of slash burns have been limited to light to moderate burns. Severe slash burns are analyzed as posing high to extreme risk to soil productivity, so data on their effects are important. The Council on Environmental Quality (CEQ) has prescribed a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, slash burns must be studied repeatedly on an array of poor, fair, and good soils in the South. The burns must be strictly controlled to produce severe effects. Such a comprehensive research program would cost several hundred thousand dollars and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

The CEQ regulations require that existing credible evidence be summarized and impacts be evaluated using accepted methods. Existing data on effects of slash burns on soil are summarized in Appendix B. The method used to evaluate impacts is:

1. Data on soil heating were compiled from slash burns in the Pacific Northwest and Australia and chaparral burns in the Pacific Southwest. These data were adjusted for southern burning conditions.

2. Data on effects of soil heating on organic matter and nitrogen were compiled from laboratory studies and the above field studies. These relationships were applied to typical levels of organic matter and nitrogen found in poor, fair, and good soils in the South to estimate degree of risk to soil productivity.

2. Effects of Mechanical Methods

Mechanical methods may affect soil productivity through nutrient displacement, soil compaction, soil erosion, and nutrient leaching.

Nutrient Displacement

Nutrient displacement is the movement of organic matter and nutrients offsite by dozer blades. Slash, litter, duff, and topsoil are moved into piles or windrows that occupy 5-10 percent of the site. Nutrients contained in the moved material are effectively lost to the site (Neary, Morris, and Swindel 1984). Raking moves nearly all litter and duff and up to two inches of topsoil, while piling moves only slash and some litter and duff.

Estimates of nitrogen lost by raking that moved 1 inch of topsoil range from 430 to 760 lb/ac (Burger 1979; Burger and Pritchett 1988; Neary, Morris, and Swindel 1984; Tew and others 1986; Tuttle, Golden, and Meldahl 1985). Burned windrows where about 0.5 inch of soil had been moved still had nitrogen contents of 230-330 lb/ac, despite large gaseous losses caused by burning (Morris, Pritchett, and Swindel 1983; Pye and Vitousek 1985). Large reductions in site pools of phosphorus, potassium, calcium, and magnesium were also reported. Reductions of nitrogen in litter and duff have ranged from 75 to 95 percent (Fox, Burger, and Kreh 1986; Morris and Pritchett 1983).

Raking may improve early stand growth by temporarily making nutrients more available and reducing competition. But later stand growth and long term soil productivity are reduced by nutrient deficiencies (especially of nitrogen and phosphorus) because organic matter that supplies nutrients over time is displaced offsite (Banker, Miller, and Davis 1983; Burger and Crutchfield 1986; Burger and Kluender 1982; Burger and Pritchett 1988; Pritchett and Morris 1982; Wells 1983). Growth losses of 20-50 percent have been measured in stands where 0.5-2.0 inches of topsoil had been removed before planting (Brendemuehl 1967; Dissmeyer 1985; Fox, Morris, and Maimone 1985; Haines, Maki, and Sanderford 1975; Pritchett 1981; Wilhite and McKee 1985).

Piling is estimated to move 90 percent of slash, 50 percent of litter and duff, and no soil from the site. Effects on site organic matter are minor and short term. About 300 lb/ac of nitrogen and 25 lb/ac of phosphorus might be removed.

Raking is estimated to move 90 percent of slash, litter and duff, and 0.4 inch of topsoil from the site. Major, long-term reductions of site organic matter occur. About 650-850 lb/ac of nitrogen and 35-40 lb/ac of phosphorus may be removed. Removal of potassium, calcium, and magnesium is 15-25 percent of site total.

CATERPILLAR

Soil Compaction

Soil compaction is caused by the weight of machinery on the ground. It increases bulk density and decreases aeration porosity. Bulk density of undisturbed topsoil is commonly 1.00-1.20 g/cc; as it climbs to 1.40 g/cc, root growth is inhibited (Gent and Ballard 1985; Simmons and Ezell 1983). Aeration porosity (soil volume in pores larger than 0.05 mm) reflects a soil's ability to store and supply air, water, and nutrients. In undisturbed topsoil, it is commonly 20-25 percent. When it drops below 10 percent, root growth is restricted (Baver, Gardner, and Gardner 1972). Compaction also reduces populations of soil biota, with recovery taking 3-5 years (Smeltzer, Bergdahl, and Donnelly 1986).

Compaction is most severe in the top 3 inches of soil. It rarely occurs below 6 inches in harvest areas, can reach to 12 inches in major skid trails, and is negligible below 12 inches (Burger and others 1985). Compaction in skid trails exceeds threshold levels of bulk density (1.40 g/cc) and aeration porosity (10 percent) throughout the top 12 inches (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Severe compaction in roads, skid trails, and log decks has been found to reduce volume of young pine stands by 50-70 percent (Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Mitchell 1979; Perry 1964). It may take 20-40 years for severely compacted soils to recover (Perry 1964; Wells and Morris 1982).

Compaction hazard depends on soil type and moisture. Sandy soils do not have a plastic limit; they do not have enough clay to become compact at any moisture level (Portland Cement Association 1973). Loamy and clay soils can be seriously compacted when soil moisture exceeds their plastic limit (Hatchell, Ralston, and Foil 1970; Moehring and Rawls 1970). The plastic limit varies from soil to soil, but is exceeded more of the time in clay soils and in floodplain and toeslope soils that receive extra moisture from upslope. Compaction hazard is highest for these soils and minimal for sandy soils

Compaction hazard also depends on ground cover and number of machine passes. Slash, litter and duff buffer the soil against vehicle pressures. Compaction increases with number of machine passes, although most is caused by the first thre passes and little occurs after 10 passes (Burger and others 1985; Hatchell, Ralston, and Foil 1970; Kreh, Burger, and Torbert 1985; Moehring and Rawls 1970; Simmons and Ezell 1983). Compaction hazard is less for methods that remove little slash, litter and duff and require 1-2 passes than fo those that remove much litter and duff and require several passes.

Studies of compaction by mechanical methods in the South are limited to chopping, raking, disking, and bedding. Choppin rarely increases bulk density or decreases aeration porosit (Blackburn, Wood, and DeHaven 1986; DeWit and Terry 1983; Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent a Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981). Changes are limited to the 0-3-inch soil depth. Bulk density increases average less t 0.05 g/cc and never approach 1.40 g/cc. Aeration porosity declines by 0-3 percent. Compaction by mowing, ripping, shearing, and scarifying, which also remove no organic material and require only 1-2 passes, is also minimal. Ripping reduces compaction in the furrows.

Raking, which removes litter and duff and involves several passes, commonly increases bulk density and decreases aerat porosity (Blackburn, Wood, and DeHaven 1986; DeWit and Terr 1983; Gent and Morris 1986; Morris and Pritchett 1983; Pehl 1984; Slay and others 1987; Stransky 1981; Tuttle, Golden, Meldahl 1985). Changes are limited to the 0-3 inch soil depth. Bulk density increases average 0.15 g/cc and may r 1.40 g/cc. Aeration porosity decreases by 5-6 percent and drop below 10 percent. Raking may reduce rainfall infiltration by 50-80 percent (Banker, Miller, and Davis 1

Disking restores bulk density and aeration porosity in the inch soil depth (Gent and others 1984). It should elimina the shallow compaction caused by harvest and site preparation. Disking to at least 12 inches is required to eliminate the deep compaction on skid trails (Hatchell 198

Harvest may increase bulk density by 0.10 g/cc and decrease aeration porosity by 3-5 percent in the 0-3 inch soil depth (Gent, Ballard, and Hassan 1983; Gent and others 1984; Gent and Morris 1986). Mowing, chopping, shearing, and scarifying are estimated to increase bulk density by 0.03 g/cc and decrease aeration porosity by 2 percent. Piling, which removes most slash and some litter and duff, is estimated to increase bulk density by 0.10 g/cc and decrease aeration porosity by 4 percent. Raking, which removes all slash, litter and duff, is estimated to increase bulk density by 0.15 g/cc and decrease aeration porosity by 6 percent.

Given pre-harvest values of 1.00-1.20 g/cc for bulk density and 20-25 percent for aeration porosity, risk of exceeding threshold bulk density or aeration porosity is minimal for mowing, chopping, ripping, shearing, and scarifying, low for piling, and medium for raking. Disking effectively mitigates compaction from harvest and site preparation.

Heavy equipment is not allowed on loamy or clay soils when the water table is within 12 inches of the surface or when soil moisture exceeds the plastic limit. This mitigation measure (section II.E.2.b.) reduces risk from compaction in harvest areas to minimal for piling and low for raking.

Soil Erosion

Mechanical methods can cause soil erosion by exposing and tilling soil. Mowing exposes almost no soil, and ripping and scarifying increase surface storage, so these tools cause negligible erosion (Miller, Beasley, and Lawson 1985). Chopping, shearing, and piling expose little soil and cause minor erosion. Disking exposes and tills the most soil and causes the most erosion.

The effect of mechanical methods on ground cover was estimated from Dissmeyer and Stump (1978) as modified by erosion research (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Pye and Vitousek 1985). USLE's cover factor is estimated at 0.000 for mowing, ripping, and scarifying; 0.003 for chopping, shearing, and piling; 0.015 for raking; and 0.060 for disking. Raking and disking require 3 years for recovery, while the other tools require only 1 year. Potential erosion is shown in table IV-11.

In table IV-11, erosion is generally less for chopping than moderate burns and for raking and disking than severe burns despite equal or higher cover factors. This is because mitigation measures for mechanical tools (section II.E.2.b.) limit chopping to average slopes of 10-25 percent, and raking and disking to average slopes of 10 percent. Slope limits do not constrain use of other methods.

Nutrient Leaching

Leaching losses from mechanical methods increase with degree of site disturbance (Blackburn, Wood, and DeHaven 1985; Fox, Burger, and Kreh 1986; Hollis, Fisher, and Pritchett 1978; Morris, Pritchett, and Swindel 1983; Riekerk 1983; Vitousek and Matson 1984). Potential nitrogen losses may be 3 lb/ac for chopping, scarifying, ripping, shearing, and piling, 10 lb/ac for raking, and 20 lb/ac for disking. Losses of other, less mobile nutrients are negligible.

Long-term Effects

Nitrogen budgets (table IV-12) show that timber harvest followed by piling produce neutral nitrogen budgets. Raking produces negative nitrogen budgets and causes long-term nitrogen depletion. Losses over one timber rotation amount to 25 percent of site total in poor soils, 18 percent in fair soils, and 15 percent in good soils. Nitrogen losses from other tools are negligible, less than 40 lb/ac.

Overall Risks

Effects on nutrient pools and soil compaction are combined to judge overall risk to soil productivity from mechanical methods. Risk is minimal for mowing, chopping, ripping, shearing, scarifying, and disking. Risk of piling is minimal on good and fair soils, and low on poor soils where it prevents long-term soil recovery. Risk of raking is extreme on poor and fair soils and high on good soils.

3. Effects of Herbicides

Effects of herbicides on soil are summarized by Neary and Michael (appendix C). Herbicides addressed in this EIS have no known effect on soil physical and chemical properties. Herbicides may affect soil productivity through biotic impacts, soil erosion, and nutrient leaching.

Biotic Impacts

Depending on application rate and soil environment, herbicides can stimulate or inhibit soil organisms. Adverse effects are observed only at concentrations well above those found in forestry field studies. Use at lowest effective rates required by mitigation measures (section II.E.2.c.) does not reduce activity of soil biota (Fletcher and Friedman 1986; Greaves and Malkoney 1980). These herbicides are not general biocides but are formulated strictly to affect the more complex metabolic processes of higher plants that are absent in microflora (appendix C).

Soil Erosion

Herbicides do not disturb soil, so treated areas usually have intact litter and duff that maintain erosion at low levels (appendix C). Selective treatments do not expose soil. Bare soil after broadcast treatments rarely exceeds 15 percent (Neary, Bush, and Grant 1986); USLE's cover factor is estimated to be 0.002 with recovery taking 1 year. Potential erosion from broadcast treatments is shown in table IV-11.

Tebuthiuron is an exception. Its high potency and persistence retard plant regrowth and interrupt litter cycling for several years (Elanco 1986). Use of tebuthiuron can seriously increase risk of erosion on steep slopes or erodible soils.

Pye and Vitousek (1985) found that broadcasting herbicides after raking and disking suppressed revegetation and produced 2.6 times the erosion of raking and disking alone. This effect was not noted after chopping, where litter and duff remained essentially intact. Broadcasting herbicides after raking, disking, or severe slash burns, which expose mineral soil over most of the area and rely on revegetation to reduce erosion, should at least double erosion from these practices.

Nutrient Leaching

Nutrient leaching after herbicide use has been little studied. Based on nitrate losses found by Neary, Bush, and Douglass (1983), nitrogen losses from broadcast treatments are less than 10 lb/ac due to suppression of vegetation uptake. Losses of other, less mobile nutrients are negligible.

Overall Risks

Nitrogen losses from erosion and leaching should not exceed 16 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. Overall risk to soil productivity from herbicides is minimal.

4. Effects of Biological Methods

Grazing can affect soil compaction, erosion, and nutrients. Degree of impact varies mostly with intensity of grazing.

Soil Compaction

Compaction hazard from grazing depends on soil type and moisture, ground cover, and grazing intensity. Light to moderate grazing increases bulk density of topsoil by only 0.05-0.08 g/cc even when combined with burning every 3 years, and 1.40 g/cc is not approached. Light to moderate grazing combined with annual burning increases bulk density by 0.10-0.15 g/cc (Suman and Halls 1955). Aeration porosity declines by 0-4 percent. Heavy grazing (overgrazing) increases bulk density by 0.10-0.25 g/cc, often beyond 1.40 g/cc. Aeration porosity declines by 8-15 percent and may drop below 10 percent.

Heavy grazing in the Blue Ridge Mountains reduced hardwood growth by 25-50 percent due to compaction. Removing livestock rectifies effects of overgrazing within 3 years (Blackburn 1984; Johnson 1952; Patric and Helvey 1986; Suman and Halls 1955; Wood and others 1987).

Biological control of mountaintop balds requires only light to moderate grazing, and burns more frequent than every 3 years are rare. Risk to soil productivity from compaction is minimal.

Soil Erosion

Erosion rates from grazed land in the East range from 0.01 to 1.01 tons/ac/yr, but seldom exceed 0.30 tons/ac/yr with light to moderate grazing (Patric and Helvey 1986). In Texas grasslands, bare soil after 28 years of grazing occupied 0-3 percent of the area studied for light grazing, 6 percent for moderate grazing, and 25 percent for heavy grazing (Blackburn 1984). In Louisiana rolling uplands, moderate grazing increased erosion on plots from 0.05 to 0.07 tons/ac (Wood and others 1987).

The effect of moderate grazing on ground cover was estimated from Dissmeyer and Stump (1978). USLE's cover factor is given a value of 0.002. Because biological methods are limited to light to moderate grazing of grassy balds with slopes rarely over 25 percent, average erosion is estimated to be 0.50-0.70 ton per acre and is mostly limited to livestock trails on sideslopes.

Soil Nutrients

Moderate grazing may slightly increase nitrogen and phosphorus in topsoil (Wood and others 1987). Nutrient leaching from grazing in the South has not been studied. Nitrogen leaching from moderate grazing is estimated to be near that for piling (3 lb/ac). Losses of other, less mobile nutrients are negligible.

Nitrogen losses from erosion and leaching should total less than 6 lb/ac. Nitrogen budgets over a timber rotation are positive and allow long-term nitrogen buildup. The impact of biological methods on soil nutrients is minimal.

5. Effects of Manual Methods

Effects of manual methods on soil are negligible. Litter and duff are left intact and revegetation is not suppressed. Risk of physical, chemical, or biological changes is minimal.

G. WATER & AQUATIC LIFE

Introduction

Water quantity and quality can be changed by actions on the land. The degree of change determines the severity of effects on aquatic life. A key water quantity concern is the size and frequency of stormflows. Water quality is the physical, chemical, and biological purity of water. Even in undisturbed forests, floods occur and water is never pure. Concerns arise when channel stability, aquatic habitat, or water use is impaired.

Aquatic life includes fish and the plants and animals that form a complex food web. The energy for this food web is supplied by organic matter delivered to or produced in the water. In streams shaded by riparian vegetation, the main source of organic matter is terrestrial leaves, branches, humus, and insects. In rivers, lakes, and ponds more exposed to the sun, the major source is aquatic plants, plankton, and decomposing plant material.

Water quantity effects are analyzed as stormflow increases. In general, the references cited in this section show that increases in total water yield are roughly proportional to increases in stormflow volume, especially in watersheds where most water yield occurs as stormflow. They also show that such increases are small and short-lived except where intense mechanical tools, severe slash burns, or heavy grazing is used. These intensive tools generally increase stormflow but not baseflow because, in addition to reducing plant water use, they expose soil, reduce infiltration, and promote surface runoff.

Water quality effects are analyzed as increases in chemicals (herbicides, nutrients), sediment, and bacteria in water. The size of these increases depends greatly on use of mitigation measures (section II.E).

Effects of rbicides

Herbicides applied to the land may unintentionally enter surface or ground water. Herbicide use may also increase stream nutrients, stormflows, and sediment yields.

Surface Water

Entry of herbicides to surface water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). Herbicides may enter streams during treatment by direct application or drift, or after treatment by surface or subsurface runoff. To pollute water, they must occur at concentrations high enough to impair water quality for human use or injure or kill aquatic plants or animals.

Direct application of herbicides to surface water occurs when streams are accidently overflown during aerial application. Risk is highest on utility lines where flight paths cross many streams, and less in timber stands where flight paths are laid out to avoid streams. Peak concentrations depend mostly on application rate and degree of overflight, and have commonly been 2.100 to 2.400 ppm in field studies where overflight was substantial (appendix C). This agrees with a recent field study of glyphosate (Payne, Feng, and Reynolds 1987). Concentrations drop below 0.050 ppm onsite within 1-2 days and decrease rapidly downstream due to mixing and dilution. But some aquatic plants and animals may be injured or killed onsite.

Drift of herbicides into surface water depends mostly on application method, existence of buffers, and weather. Drift potential occurs only in foliar applications, is greater for broadcast than selective treatments, increases from hand to mechanical to aerial tools, and decreases from small to large droplets to granules. Drift increases with wind, but buffers moderate its effects. Peak concentrations in streams from aerial spraying of fine droplets with 50-70 foot buffers have commonly been 0.130 to 0.148 ppm in field studies (appendix C). Mitigation measures (section II.E.2.c.) require application of granules or large droplets in favorable weather, using clearly marked buffers of 200 feet (aerial) and 30 feet (ground), so peak concentrations from aerial drift should rarely exceed 0.050 ppm (appendix A). Applying glyphosate as large droplets by air with an 82-foot buffer produced a peak concentration of only 0.002 ppm (Payne, Feng, and Reynolds 1987).

After treatment, herbicides may enter streams by subsurface flow or by movement in ephemeral channels. Key factors affecting peak concentration are presence of buffers, storm size, herbicide application rate and properties (mobility and persistence), and downstream mixing and dilution.

Perennial and intermittent streams are protected by 30-foot (ground) and 200-foot (aerial) buffers. Herbicides applied along these streams must move through the buffer and are subject to dilution and mixing in transit. If ephemeral streams are not buffered, herbicides applied directly to them are usually picked up in streamflow by the first storm large enough to create flow in the channels.

Large storms rarely produce high herbicide concentrations in streams because herbicides are diluted by large water volumes. Small storms may not produce enough flow to move herbicides into streams. Intermediate storms produce the highest concentrations (appendix C).

Potential herbicide concentration in streams is proportional to application rate. Lowest effective rates required by mitigation measures (section II.E.2.c.) are 0.1-4.0 lb/ac except for fosamine and are a fraction of the label rate. Selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential entry to streams. Herbicide mobility depends on water solubility and adsorption (soil bonding) tendency. The potentially most mobile of our studied herbicides are 2,4-D (extreme solubility, low adsorption), picloram (high solubility, low adsorption), and hexazinone (moderate solubility, minimal adsorption). Conversely, 2,4-DP, sulfometuron methyl, and triclopyr have minimal solubility, and fosamine and glyphosate are extremely adsorptive (appendix C, table 1).

Herbicide persistence depends on degradation modes and rates. Tebuthuiron is extremely persistent (half-life 392 days), because it degrades only by slow microbial action. Picloram and glyphosate are moderately persistent (half-life 60-65 days). Picloram degrades mainly by direct sunlight, and microbial degradation is slow. Glyphosate degrades mainly by microbial action but not by sunlight. Conversely, persistence of 2,4-DP, fosamine, and sulfometuron methyl is minimal (half-life 10 days), due mainly to rapid microbial degradation (appendix C, table 1).

Based on mobility and persistence, our studied herbicides with the most potential for subsurface movement to streams through buffers are 2,4-D, picloram, and hexazinone. In field studies where herbicides were applied at lowest effective rates using typical buffer widths, peak concentrations in streams have been less than 0.050 ppm (appendix C). Despite its extreme persistence, tebuthiuron has only moderate potential for movement to streams due to its low solubility and moderate adsorption. Glyphosate has low potential because its moderate persistence is more than offset by its extreme adsorption.

Herbicide mobility has less effect on herbicide levels in ephemeral streams if buffers are not used and herbicides are applied directly to the channel. Persistence is important because it determines how much herbicide is still present in the channel when the next flow-producing storm occurs. Herbicides can be mobilized in solution or with sediment. Peak concentrations in field studies have ranged from 0.180 to 0.550 ppm (appendix C).

Dilution by water inflow and mixing by turbulence rapidly reduce herbicide concentrations downstream. As watershed size doubles, peak herbicide concentration should drop to 1/4 its initial level (Neary, Bush, and Douglass 1983). For example, a peak concentration of 0.500 ppm in an unprotected ephemeral stream with a 10-acre watershed will likely drop to 0.050 ppm by the time it reaches a small perennial stream with a 50-acre watershed and 0.001 ppm in a large stream with a 2,500-acre watershed.

Mitigation measures (section II.E.2.c.) require buffers along perennial and intermittent streams, and mixing and dilution rapidly reduce concentrations delivered by unbuffered ephemeral streams. Peak concentrations of some herbicides in small, headwater perennial streams due to drift or runoff may range up to 0.050 ppm in some cases. Even if we apply EPA's strictest drinking water standard (0.100 ppm for 2,4-D) to all our studied herbicides, these concentrations pose minimal risk to water quality for public health or aquatic plants and animals. For example, 0.926 ppm of hexazinone do not affect aquatic algae, invertebrates, or fish (Neary, Bush, and Douglass 1983). Picloram affects many vegetable crops at concentrations as low as 0.010 ppm (Baur, Bovey, and Merkle 1972), so it should be used with care near water used for irrigation.

Accidental direct application to streams occurs on some aerial treatments, especially utility lines. Risk to water quality is generally minimal where mixing and dilution are substantial, as in municipal watersheds whose reservoirs exceed 5 acre-feet. But tebuthiuron poses high risk due to its extreme persistence; 28 percent remains after 2 years, and 2 percent after 6 years.

Wetlands, Rivers, and Estuaries

Effects on wetland vegetation are minimal because buffers keep herbicide concentrations below 0.050 ppm. Mixing and dilution reduce herbicide concentrations to 0.001 ppm long before they reach rivers or estuaries, so effects on them are negligible.

Effects on Aquatic Animals

Appendix A discloses acute, chronic, and cumulative herbicide effects on aquatic animals. Studied chemicals with at least moderate acute toxicity to fish, amphibians, or invertebrates are 2,4-D, ester, 2,4-DP, dicamba, diesel oil, glyphosate (Roundup), kerosene, limonene, picloram, and triclopyr ester (appendix A, pages 6-15 to 6-42). Toxic risk of herbicide concentrations is rated as nil for less than 0.1 LC_{50}, slight for 0.1-0.5 LC_{50}, and significant for more than 0.5 LC_{50} (EPA 1986a). Tables IV-13 and IV-14 show toxic risk to selected aquatic animals resulting from accidental spills of herbicides.

Risk of **acute toxicity** from drift or runoff of any chemical is nil. Risk from an accidental spill is slight for sulfometuron methyl and significant for 2,4-D ester, 2,4-DP, diesel oil, glyphosate (Roundup), kerosene, limonene, and triclopyr ester. No risk results from accidental spill of the other chemicals (appendix A, tables 8-17 to 8-33).

Data on **chronic toxicity** to aquatic animals are limited. Data on one species exist for 2,4-D ester, sulfometuron methyl, and triclopyr. Good data exist only for 2,4-D amine. Risk of chronic effects, such as reproduction or long term survival, were estimated for combinations of species and herbicides with sufficient data. No significant risk was identified.

Cumulative effects occur only if a herbicide accumulates in the body. Tebuthiuron shows a slight tendency to accumulate in fish. The other studied herbicides show no such tendency (appendix A, table 3-4), and risk from cumulative exposure should not exceed other risks addressed in appendix A due to mixing, dilution, and rapid degradation. Herbicide mixtures used on national forests have not shown synergistic effects.

Ground Water

Entry of herbicides to ground water is discussed in the Risk Assessment (appendix A) and by Neary and Michael (appendix C). After treatment, herbicides may move into aquifers by vertical seepage. To pollute ground water, they must occur at concentrations high enough to impair water quality for human use. Key factors affecting peak concentration are herbicide application rate, mobility, and persistence; soil type; depth to water table; and distance to point of use.

Potential herbicide concentration in ground water is proportional to application rate. As discussed earlier, our low rates are a fraction of the label rate and selective treatment further reduces rates by 40-70 percent.

Herbicide mobility and persistence affect potential for seepage. Mobility depends on solubility and adsorption, and persistence depends on degradation mode and rate. As discussed earlier, the potentially most mobile herbicides are 2,4-D, picloram, and hexazinone, and the most persistent ones are tebuthiuron, picloram, and glyphosate. Mobility and persistence properties suggest that herbicides with at least a moderate seepage potential include 2,4,-D, dicamba, hexazinone, imazapyr, picloram, and tebuthiuron.

Table IV-13.—Risk of exposure of fish and aquatic animals from an accidental terrestrial spill of herbicide or adjuvant. Terrestrial spill is assumed to be an amount equal to that carried in a a single container in a pickup truck (5 gal (19 l)). All chemical is assumed to reach the water (a pond). NR = No risk (according to the EPA standard) dose is less than 1/10 LC_{50}; SL = Slight risk (can be mitigated), dose between 1/10 and 1/2 LC_{50}; ■ = Severe risk, dose is larger than 1/2 LC_{50}; — = No information available.

	2,4-D AMINE	2,4-D ESTER	2,4-DP	DICAMB	DIESEL	FOSAMI	GLYPHO RODEO	GLYPHO ROUNDU	HEXAZI	IMAZAP	KEROSE	LIMONE	PICLOR +2,4-D	SULFOM
Rainbow trout	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Brook trout	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Largemouth bass	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Smallmouth bass	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Bluegill	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Green sunfish	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Fathead minnow	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Gizzard shad	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Northern hogsucker	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Mosquitofish	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Chain pickerel	NR	SE	SE	NR	SE	NR	NR	SE	NR	NR	SE	SE	NR	SL
Crayfish	NR	NR	NR	—	SL	NR	—	NR	NR	—	NR	—	—	NR
Water flea	SL	SL	SL	NR	—	NR	NR	SL	NR	NR	—	—	NR	SL
Stonefly nymph	—	SE	SE	—	—	—	—	SL	—	—	—	—	NR	—
Virignia oyster	—	SL	SL	—	—	—	—	—	NR	—	—	—	NR	—
Mudpuppy	NR	—	—	NR	—	—	—	—	—	—	—	—	NR	—

	TEBUTH	TRICLO AMINE	TRICLO ESTER
Rainbow trout	NR	NR	SE
Brook trout	NR	NR	SE
Largemouth bass	NR	NR	SE
Smallmouth bass	NR	NR	SE
Bluegill	NR	NR	SE
Green sunfish	NR	NR	SE
Fathead minnow	NR	NR	SE
Gizzard shad	NR	NR	SE
Northern hogsucker	NR	NR	SE
Mosquitofish	NR	NR	SE
Chain pickerel	NR	NR	SE
Crayfish	NR	NR	—
Water flea	NR	NR	—
Stonefly nymph	—	—	—
Virignia oyster	NR	NR	—
Mudpuppy	—	—	—

Table IV-14.—Risk of unacceptable exposure of fish and aquatic animals from an accidental aerial spill of herbicide or adjuvant. Spill is assumed to be an emergency helecopter tank-dump of 100 gal (379 l). All chemical is assumed to reach the water (a resevoir). NR = No risk (according to the EPA standard) dose is less than 1/10 LC_{50}; SL = Slight risk (can be mitigated), dose between 1/10 and 1/2 LC_{50}; ■ = Severe risk, dose is larger than 1/2 LC_{50}; — = No information available.

	2,4-D AMINE	2,4-D ESTER	2,4-DP	DIESEL	FOSAMI	GLYPHO RODEO	GLYPHO ROUNDU	HEXAZI	IMAZAP	KEROSE	LIMONE	PICLOR +2,4-D	SULFOM	TEBUTH
Rainbow trout	NR	SL	SL	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Brook trout	NR	SL	SL	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Largemouth bass	NR	SL	SL	SL	NR	NR	NR	NR	NR	SE	NR	NR	NR	NR
Smallmouth bass	NR	SL	SL	SL	NR	NR	NR	NR	NR	SE	NR	NR	NR	NR
Bluegill	NR	SL	SL	SL	NR	NR	NR	NR	NR	SE	NR	NR	NR	NR
Green sunfish	NR	SL	SL	SL	NR	NR	NR	NR	NR	SE	NR	NR	NR	NR
Fathead minnow	NR	NR	NR	SL	NR	NR	NR	NR	NR	SE	NR	NR	NR	NR
Gizzard shad	NR	SL	SL	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Northern hogsucker	NR	SL	NR	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Mosquitofish	NR	SL	SL	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Chain pickerel	NR	SL	SL	SL	NR	NR	SL	NR	NR	SE	NR	NR	NR	NR
Crayfish	NR	NR	NR	NR	NR	—	NR	NR	—	NR	—	—	NR	NR
Water flea	NR	NR	NR	—	NR	NR	NR	NR	NR	—	—	NR	NR	NR
Stonefly—ymph	—	SL	NR	—	—	—	NR	—	—	—	—	NR	—	—
Virignia oyster	—	NR	NR	—	—	—	—	NR	—	—	—	NR	—	NR
Mudpuppy	NR	—	—	—	—	—	—	—	—	—	—	NR	—	—

	TRICLO AMINE	TRICLO ESTER
Rainbow trout	NR	SL
Brook trout	NR	SL
Largemouth bass	NR	SL
Smallmouth bass	NR	SL
Bluegill	NR	SL
Green sunfish	NR	SL
Fathead minnow	NR	SL
Gizzard shad	NR	SL
Northern hogsucker	NR	SL
Mosquitofish	NR	SL
Chain pickerel	NR	SL
Crayfish	NR	—
Water flea	NR	—
Stonefly—ymph	—	—
Virignia oyster	NR	—

Herbicides move most easily through sand, which is most porous and has the least adsorption potential. Potential for ground water contamination increases as depth to water table and distance to point of use decrease.

The Risk Assessment (appendix A) models herbicide contamination of ground water under conditions likely to produce high concentrations. Herbicides are applied at maximum rates to the soil surface. They are then leached through 3 feet of sandy loam soil by 50-60 inches of annual rainfall. The water table is only 3 feet deep, and the aquifer is sand. In the model, only dicamba, hexazinone, imazapyr, picloram, and tebuthiuron reach the water table even 10 percent of the time. Concentrations in ground water directly under the treated area exceed 0.001 ppm only for hexazinone (0.004), dicamba (0.005), and tebuthiuron (0.008). Only tebuthiuron, with its 392-day half-life, moves outside the treatment area; maximum concentration at 330 feet is 0.002 ppm 1 year after treatment.

Field studies show that, applied at our low rates, 2,4-D, sulfometuron methyl, and triclopyr do not seep to shallow ground water, and hexazinone and picloram should reach peaks of less than 0.025 ppm (appendix C).

Applied at lowest effective rates, herbicides should not occur in shallow ground water at concentrations exceeding a small fraction of EPA's strictest drinking water standard. Deeper aquifers tapped by wells should have negligible concentrations. Risk to ground water quality is minimal, especially since mitigation measures (section II.E.2.c.) require a buffer around all water sources that reduces herbicide concentrations through mixing and dilution. But tebuthiuron, due to its extreme persistence, may build up in shallow ground water if used every few years on utility lines.

In theory, risk to ground water quality is higher in karst areas because herbicide entry may occur in concentrated runoff through sinkholes or bedrock fissures. To reduce this risk, herbicides may only be applied selectively (directly to individual plants) on rock outcrops or sinkholes (section II.E.2.c.). This mitigation lowers thei effective application rate and their availability for surface or subsurface runoff. In addition, dilution in karst systems is very high. Herbicides in karst ground water should not exceed concentrations in shallow sand aquifers (0.025 ppm). Effects on karst aquatic biota shoul be minimal.

Some herbicides used in agriculture have been found in ground water. However, the potential for ground water contamination is many times greater in agriculture than on national forests for two reasons:

1. In agriculture, herbicides are usually broadcast at label rates, which are 3 to 50 times the rates allowed on national forests by our mitigations (section II.E.2.c.).

2. In intensive agriculture practices, herbicides may be applied 3 times per year. On national forests, they are applied once or twice every 50 to 120 years for timber growth and once every 3 to 4 years for wildlife and balds habitat. In the general forest, all studied herbicides except tebuthiuron are fully degraded long before the next treatment.

Figure IV-3 shows relative onsite loading of a herbicide with a 30-day half-life used in agriculture (3 times per year) versus national forests over a 5-year period. Many times more herbicide resides onsite and is available for leaching to ground water in the agricultural site than in the forest.

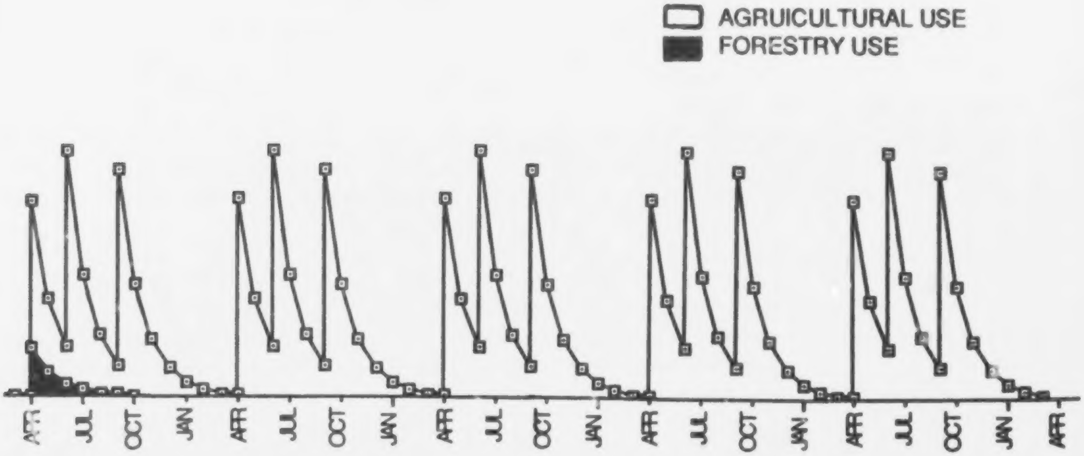


Figure IV-3.--Relative onsite loading of a herbicide with a 30-day half-life used in agriculture (at label rate) versus national forests (at 1/4 label rate) over a 5-yea period.

Stream Nutrients

Broadcast use of the studied herbicides at lowest effective rates may produce minor increases in stream nutrients such as nitrates. Increases are short-lived due to minimal soil disturbance and prompt regrowth. Drinking water standards are not exceeded if mitigation measures (section II.E.2.c.) are employed (Neary, Bush, and Grant 1986). Increases are less where treatments are selective or streams are buffered.

Stormflows

Effects of low-rate herbicides on stormflows are minor because soil infiltration capacity is generally maintained (Lloyd-Reilley, Scifres, and Blackburn 1984). Selective application does not increase stormflows because plant water use is little affected. Broadcast application may produce small increases by reducing plant water use, with typical increases in average stormflow volumes and peaks of about 40 percent for 1 year in small (1-3 acre) watersheds (Neary, Bush, and Grant 1986).

Tebuthiuron may produce larger increases. Its high potency and persistence retard plant regrowth and interrupt litter cycling for several years (Elanco 1986). Bare soil and surface runoff may increase substantially.

Sediment Loads

Sediment is produced by surface and channel erosion. Surface erosion is minimal in undisturbed forests and is caused by soil exposure and tillage. Channel erosion occurs even in undisturbed forests and increases with peak flows.

Potential surface erosion is shown in Table IV-11. Only a fraction of surface erosion becomes sediment. This fraction (sediment delivery ratio) increases with steeper slopes and denser drainage networks and is reduced by buffers along streams. Because perennial and intermittent streams are protected by buffers, eroded soil is delivered almost solely to ephemeral streams.

Data on average slope steepness and drainage density were used to derive sediment delivery ratios (appendix B) and sediment yields from surface erosion for the various landtypes (Table IV-15). Selective herbicide treatments expose no soil and cause no surface erosion. Broadcast treatments expose little soil and cause minor surface erosion (Neary, Bush, and Grant 1986).

Data isolating channel-eroded sediment from surface-eroded sediment are scarce. Channel sediment increases with peak flow. Increases from broadcast herbicide application should be proportional to increases in average peak flow, typically 40 percent for 1 year (Neary, Bush, and Grant 1986).

2. Effects of Mechanical Methods

Mechanical methods may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on degree of disturbance, topography, and soil type.

Table IV-15.--Sediment delivery ratios and sediment yields (tons per acre) for treatments by landtype

Landtype	Sediment Delivery Ratio	Mod. Burns Herbicides	Chop/ Shear Pile*	Rake*	Severe Burns	Disk*
BLUE RIDGE						
Narrow Ridge	.08	.063	.038	.063	.473	.254
Blue Ridge Mtns.	.09	.137	.096	.112	1.029	.447
Unaka Mtns.	.09	.110	.076	.089	.823	.357
RIDGE AND VALLEY						
Folded Highlands	.08	.059	.046	.076	.441	.305
Faulted Lowlands	.07	.081	.053	.142	.610	.568
APPALACHIAN PLATEAUS						
Cumberland Mtns.	.08	.068	.052	.088	.509	.353
Kentucky Basin	.07	.059	.038	.103	.434	.412
Table Plateaus	.06	.029	.023	.117	.218	.468

*Sediment from mechanical tools would be greater if mitigation measures did not require contour treatments limited to average slopes of 10-25 percent for chop and 10 percent for rake and disk.

Stream Nutrients	Mechanical methods may increase stream concentrations of some nutrients. Drinking water standards are not exceeded if mitigation measures (section II.E.2.b.) are employed (Fox, Burger, and Kreh 1986; Hewlett 1979; Hollis, Fisher, and Pritchett 1978; Riekerk 1985). Most mountain aquatic systems are nutrient poor, so small increases in nutrients often increase their productivity.
Stormflows	Mechanical methods can increase stormflow volumes and peaks in small watersheds. Mowing causes no increases because it exposes little soil and does not reduce water use by plants. Scarifying causes no increases because it disturbs little soil and increases surface water storage. Contour ripping may decrease stormflow volumes and peaks by increasing surface storage and infiltration and by altering subsurface flow patterns (Miller, Beasley, and Lawson 1985). Chopping, shearing, and piling retain soil infiltration capacity and cause small stormflow increases by reducing water use by plants. Raking and disking cause larger increases by reducing infiltration and promoting surface runoff. Large increases may affect aquatic biota by eroding and baring streambanks and by scouring and silting streambeds.

In small (1-15 acre), full-treated watersheds, typical increases in average stormflow volumes and peaks are 40 percent for 1 year for chopping, shearing, and piling, and 200 percent for raking and disking with return to pre-treatment levels taking 3 years or more (Beasley and Granillo 1985a; Blackburn, Wood, and DeHaven 1986; Blackburn and others, 1987; Douglass, Van Lear, and Valverde 1983; Miller, Beasley, and Lawson 1988a; Swindel, Lassiter, and Riekerk 1983a, 1983b; Ursic 1986; Van Lear and Douglass 1982). However, Miller, Beasley, and Lawson (1985) found that chopping caused increases below typical levels in some of their watersheds in one Ouachita Mountains study.

Sediment Loads

Mechanical methods can increase sediment loads from both surface and channel erosion in small watersheds. Amount of increase is related to degree of disturbance (Beasley 1979; Beasley and Granillo 1985a, 1985b; Beasley, Granillo, and Zillmer 1986; Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987; Douglass and Goodwin 1980; Ursic 1986).

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Mowing, scarifying, and ripping cause negligible surface erosion; mowing exposes little soil, and scarifying and ripping trap soil onsite (Miller, Beasley, and Lawson 1985). Chopping, shearing and piling expose some soil and cause minor surface erosion. Disking exposes and tills the most soil and causes the most erosion.

Channel sediment tends to increase in proportion to average peak flow (Blackburn, Wood, and DeHaven 1986; Blackburn and others 1987), with typical first-year increases is small (1-15) acre) watersheds of about 40 percent for chopping, shearing, and piling, and 200 percent for raking and disking. Larger increases occur from any mechanical method if stream channels are not protected from disturbance by equipment (Miller, Beasley, and Lawson 1988b).

Large sediment increases may block sunlight, impair photosynthesis by algae and aquatic plants, and erode gill filaments of fish and aquatic invertebrates. Once deposited, the sediment can bury aquatic plants and insects, be imbedded in spawning gravels to smother eggs and prevent fry emergence, and fill in deep pools that are vital for fish cover. Sediment increases are minor where raking and disking are not used and mitigation measures (section II.E.2.b.) are used that limit soil exposure, contour soil disturbances, and employ filter strips along streams.

3. Effects of Prescribed Fire

Prescribed fire may increase stream nutrients, stormflows, and sediment loads. In general, amount of increase depends on fire severity.

Stream Nutrients

Slash burns may produce minor increases in concentrations of some nitrogen compounds and cations, but drinking water standards are not exceeded even by severe burns. Underburns and grassland burns have no significant effect (appendix B).

Stormflows

Moderate slash burns may increase average stormflow volumes and peaks by about 40 percent for 1 year by reducing water use by remaining vegetation. Severe burns cause greater, more prolonged increases by exposing mineral soil and promoting surface runoff (appendix B).

Underburns and grass burns are light to moderate. Underburns do not affect water use, and grass burns only affect it for a few weeks until grass regrows. These burns do not significantly affect stormflows (appendix B).

Sediment Loads

Sediment delivery ratios were applied to erosion rates to derive sediment yield from surface erosion for the various landtypes (Table IV-15). Moderate slash burns expose little soil and cause minor surface erosion, but severe slash burns expose much soil and cause substantial erosion (appendix B). Channel sediment increases in proportion to average peak flow (Ursic 1970), with first-year increases estimated to be about 40 percent for moderate slash burns and 200 percent for severe slash burns. Sediment increases are minor where severe slash burns are not used and filter strips (section II.E.2.a.) are employed along streams.

4. Effects of Biological Methods

Grazing minimally increases stream concentrations of nutrients. Livestock with access to streams increase harmful bacteria in the water, which may remain elevated for months after livestock removal if animal wastes are dropped in or next to the channel. When livestock are prevented from concentrating near streams, animal wastes are processed by litter, duff, and soil and counts of aquatic bacteria rarely exceed water quality standards (Patric and Helvey 1986; Tiedemann and others 1987). Mitigation measures (section II.E.2.d.) require livestock to be managed to prevent water contamination and streambank damage and grazing is confined to grassy balds remote from streams, so risk to public health is minimal.

Light to moderate grazing commonly reduces soil infiltration capacity by less than 50 percent. Heavy grazing reduces it by 50-90 percent (Blackburn 1984; Patric and Helvey 1986; Wood and others 1987). In Oklahoma and Texas grasslands, 20-30 years of continuous overgrazing increased runoff by more than 100 percent and sediment yield by 10-26 times above moderate rotation grazing (Blackburn 1984).

Light to moderate grazing increases stormflows slightly by reducing soil infiltration capacity and plant water use. Biological methods are limited to light to moderate grazing of grazzy mountaintop balds where streams are scarce, so sediment yield from surface erosion should rarely exceed

0.050 tons per acre. Channel sediment increases in proportion to peak flow, estimated to be about 40 percent for 1 year.

5. Effects of Manual Methods

Manual methods do not increase stormflow volumes and peaks substantially because plant water use is little affected. Stream nutrients and sediment loads are not increased because litter and duff are left intact and revegetation is not suppressed.

6. Watershed Analysis

Cumulative effects on water include the combined effects of vegetation management and timber harvest onsite, plus those of all other management on all other lands in a watershed. All these effects must be integrated and compared with tolerance limits for the watershed. Cumulative effects analyzed are increased herbicide concentrations, stormflows, and sediment loads.

Cumulative effects were analyzed on typical watersheds in the Appalachians. Three large (20,000+ acre) watersheds were used to assess cumulative effects heavily influenced by private management. Eight small (4,040-9,900 acre) watersheds that represent each major landtype were used to assess cumulative effects dominated by Forest Service management (Table IV-16).

Table IV-16.--Land use data for typical watersheds, cumulative water effects

Watershed	Landtype	National Forest	Total Acres	Gov't Acres	------Private Acres------ Timber	Crop	Pasture	Mines
DAVIDSON R	BLUE RIDGE	Pisgah	25,860	25,860	0	0	0	0
Otter Ck	Narrow Ridge	G.Washington	6,300	5,430	850	20	0	0
Avery Ck	Blue Ridge Mtns	Pisgah	4,040	4,040	0	0	0	0
North R	Unaka Mtns	Cherokee	7,300	7,300	0	0	0	0
DRY R	RIDGE & VALLEY	G.Washington	40,580	35,100	5,480	0	0	0
Skidmore Fk	Folded Highlands	G.Washington	9,900	9,700	200	0	0	0
Hillabee Ck	Faulted Lowlands	Talladega	7,160	6,480	680	0	0	0
INDIAN CR	APPAL PLATEAUS	Daniel Boone	25,000	18,150	6,100	0	710	40
Barren Fk	Kentucky Basin	Daniel Boone	6,700	6,200	390	0	110	0
Stony Ck	Cumberland Mtns	Jefferson	6,800	5,760	1,040	0	0	0
Brushy Ck	Table Plateaus	Bankhead	7,680	7,040	640	0	0	0

Cumulative effects are most rigorously analyzed on the 8 small watersheds. Forest Service land makes up most of their area and downstream mixing and dilution are limited. They were chosen to represent differences in topography, earth materials, and runoff-erosion response to management. Figure IV-4 shows the landtypes in the Appalachians and throughout the South.

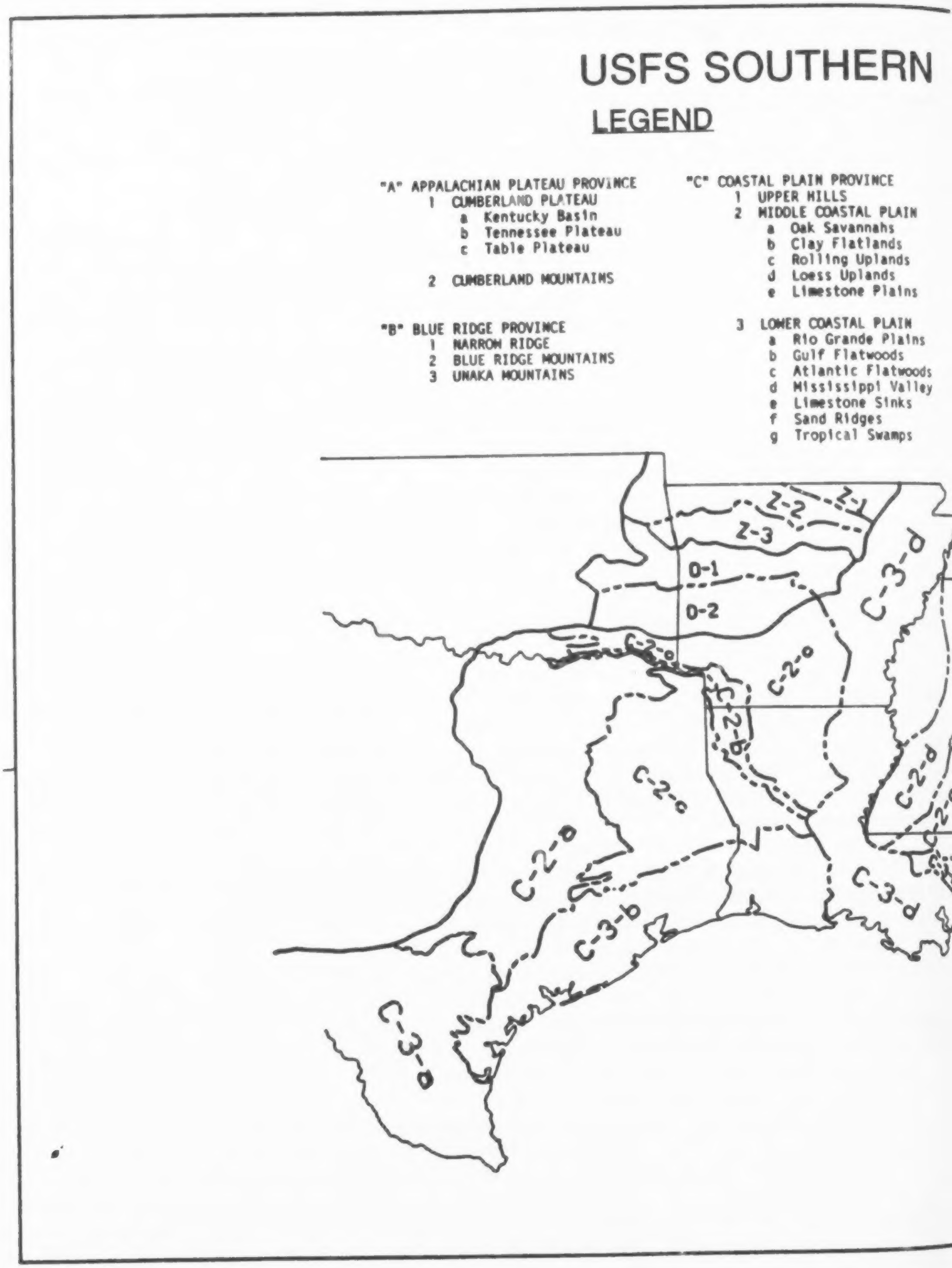

USFS SOUTHERN
LEGEND
"A" APPALACHIAN PLATEAU PROVINCE
1 CUMBERLAND PLATEAU
a Kentucky Basin
b Tennessee Plateau
c Table Plateau
2 CUMBERLAND MOUNTAINS
"B" BLUE RIDGE PROVINCE
1 NARROW RIDGE
2 BLUE RIDGE MOUNTAINS
3 UNAKA MOUNTAINS
"C" COASTAL PLAIN PROVINCE
1 UPPER HILLS
2 MIDDLE COASTAL PLAIN
a Oak Savannahs
b Clay Flatlands
c Rolling Uplands
d Loess Uplands
e Limestone Plains
3 LOWER COASTAL PLAIN
a Rio Grande Plains
b Gulf Flatwoods
c Atlantic Flatwoods
d Mississippi Valley
e Limestone Sinks
f Sand Ridges
g Tropical Swamps
Z-2
Z-1
Z-3
D-1
D-2
C-3-d
C-2-a
C-2-b
C-2-a
C-2-a
C-2-d
C-2-a
C-3-d
C-3-b
C-3-a

Figure IV-4.--Landtypes of the Appalachian Mountains

REGION LANDTYPES

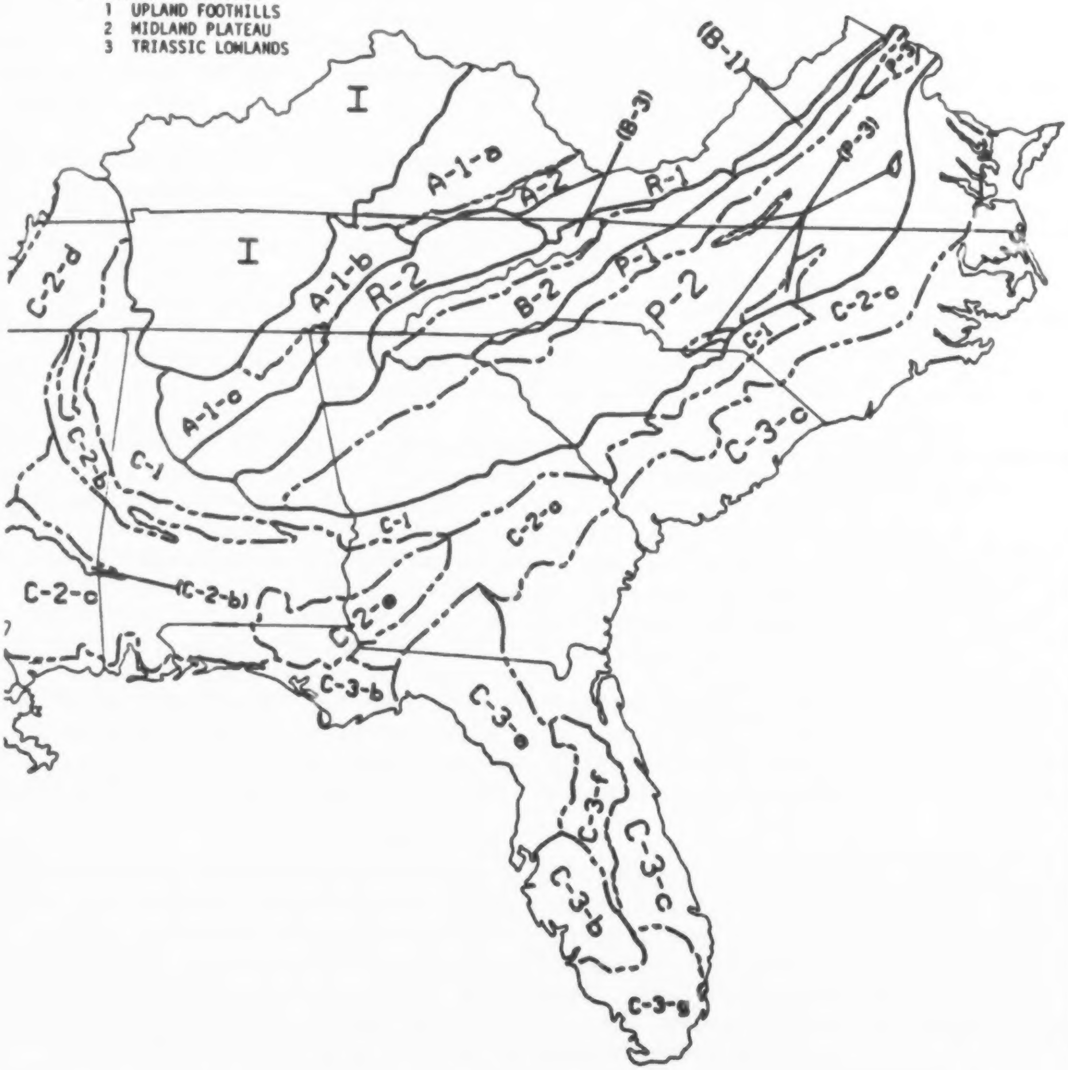
"I" INTERIOR LOW PLATEAUS PROVINCE

"O" QUACHITA PROVINCE
  1 ARKANSAS VALLEY
  2 QUACHITA MOUNTAINS

"R" RIDGE AND VALLEY PROVINCE
  1 FOLDED HIGHLANDS
  2 FAULTED LOWLANDS

"Z" OZARK PLATEAUS PROVINCE
  1 SALEM PLATEAU
  2 SPRINGFIELD PLATEAU
  3 BOSTON MOUNTAINS

"P" PIEDMONT PROVINCE
  1 UPLAND FOOTHILLS
  2 MIDLAND PLATEAU
  3 TRIASSIC LOWLANDS


(B-1)
(P-3)
I
(B-3)
A-1-a
A-2
R-1
(P-3)
I
C-2-d
A-1-b
R-2
B-2
P-1
P-2
C-2-a
C-1
A-1-c
C-3-a
C-2-b
C-1
C-1
C-2-a
C-2-a
(C-2-b)
C-2-a
C-1
C-3-b
C-3-e
C-3-f
C-3-c
C-3-b
C-3-g

Herbicide Concentrations

Herbicides used on national forests are applied at low rates, separated from perennial and intermittent streams by buffers, and subject to considerable downstream mixing and dilution. In the maximum herbicide alternative (H), assuming all eligible acres are treated in the same year, less than 9 percent of the watershed is herbicide-treated on national forest land in every watershed. Maximum herbicide concentrations due to national forest use at the mouth of the watersheds should never exceed 0.025 ppm unless herbicides are accidently applied directly to surface water.

Herbicides used on private farmland are usually applied every year, at higher rates, and along streams with narrow or no buffers. Peak concentrations measured in runoff range from 1.800 to 5.200 ppm (Wauchope 1978). Considered alone or in addition to other management, risk to water quality from typical application on Forest Service land is minimal.

Stormflows

Timber harvest increases average stormflow volumes and peaks in proportion to percent of stems cut. Increases from clearcut 1-16 acre watersheds average 40 percent for 1 year (Douglass, Van Lear, and Valverde 1983; Settergren and Krstansky 1987; Ursic 1970). Additional first year increases in 1-15-acre watersheds are: 40 percent for broadcast herbicides, chopping, shearing, piling, grazing, and moderate slash burns; and 200 percent for disking, raking, and severe slash burns.

Stormflow peaks are subject to considerable flattening downstream from turbulence and dilution. Increases from clearcut 74-108 acre watersheds average only 5-10 percent for one year (Hewlett and Helvey 1970; Patric 1980; Reinhart, Eschner, and Trimble 1963). Unchanged flows coming from undisturbed portions of a watershed further moderate increases from disturbed portions. In the maximum treatment alternative (H), average stormflow increases at the mouth of the watersheds due to national forest management are 1-4 percent. Adding the effects of private land management, stormflow increases range from 1 to 6 percent, except for Indian Creek (8 percent) due to a large projected amount of intensive site preparation on private land.

This analysis inflates estimated stormflow increases because it assumes that maximum rates of timber harvest are used, all eligible acres are treated in the same year, and stormflows from national forest and private lands are synchronized. Such conditions are rare in actual practice. In addition, these increases represent average-sized stormflows. Increases during large floods, which cause nearly all flood damage and occur when soils over the entire watershed are saturated, would be much less and negligible in all watersheds.

Sediment Loads

Channel erosion occurs even in undisturbed forests. Typical annual sediment yields from channel erosion in undisturbed small watersheds in good hydrologic condition are 100 lb/ac in the Blue Ridge province, 40 lb/ac in the Ridge and Valley province, and 30 lb/ac in the Appalachian Plateaus province (Douglass and Swank 1975; Kochenderfer, Helvey, and Wendel 1987; Monk 1975; Patric 1980; Swank and Waide 1988; Ursic 1986).

Channel erosion increases in proportion to average peak flow. In this analysis, clearcuts are estimated to increase channel sediment an average of 40 percent for 1 year. Additional increases are estimated to be: 40 percent for broadcast herbicides, chopping, shearing, piling, grazing, and moderate slash burns; and 200 percent for disking, raking, and severe slash burns. Increases in channel sediment are estimated at 40 percent for pasture land and 200 percent for cropland.

In addition to vegetation management, surface-eroded sediment is increased by timber harvest, agricultural use, and roads. Typical rates of surface erosion for these uses were combined with sediment delivery ratios for the various landtypes to estimate surface-eroded sediment. Estimates of channel and surface sediment were combined to derive total 10-year sediment yield for each watershed (Table IV-17).

High rates of timber harvest and alternative H were modeled to show a maximum effect. **Channel erosion** was computed by multiplying acres treated by the proper increase rate for each practice. **Surface-eroded sediment** was computed as follows:

1. For roads, acres of road were multiplied by typical erosion rates for dirt, gravel, and paved roads. Existing roads are permanent and erode every year. New timber access roads are open temporarily and erode for only 1 year.

2. For timber harvest, cropland, and pasture, acres treated were multiplied by USLE factors for each watershed. Cover factors (USFS and private) are 0.002 and 0.005 for timber harvest, 0.003 for pasture, and 0.020 for cropland (Dissmeyer and Stump 1978). Skid trails, with higher erosion rates, cover 5 and 10 percent of timber harvest. Cropland and pasture erode every year but timber harvest normally erodes for only 1 year.

3. For vegetation management (alternative H), acres treated were multiplied by erosion values in table IV-13. On private forest land, site preparation was assumed to be all

disking, and the resulting erosion was added to private timber harvest in the "forest" category.

4. In each category, the computed erosion was multiplied by a sediment delivery ratio (SDR) to derive the sediment values in table IV-17. The SDR assumes a sediment source zone whose width in feet is 50 plus 3.0 times percent slope for roads and 40 plus 1.4 times percent slope for areal treatments (Swift 1986). Filter strips occur along perennial and intermittent streams on national forests, perennial streams only on private forest land, and seldom on private crop and pasture land.

Table IV-17.--Cumulative 10-year sediment yields (tons) for typical watersheds

		Davidson	Otter	Avery	North	Dry	Skidmore	Hillabee	Indian	Stony	Barren	Brushy
NATURAL		12,930	3,150	2,020	3,650	8,116	1,980	1,432	3,750	1,020	1,005	1,152
FS:	Roads	4,646	715	842	2,842	2,375	1,533	283	1,199	947	469	320
	Harvest	218	56	44	59	322	60	75	201	79	47	40
		4,864	771	886	2,901	2,697	1,593	358	1,400	1,026	516	360
PVT:	Roads	672	754	-	-	865	188	161	1,443	398	321	-
	Forest	-	185	-	-	900	102	148	1,006	192	64	55
	Crop	-	108	-	-	-	-	-	-	-	-	-
	Pasture	-	-	-	-	-	-	-	888	-	138	-
	Mines	-	-	-	-	-	-	-	368	-	-	-
		672	1,047	0	0	1,765	290	309	3,705	590	523	55
VEG MGT (ALT. H)		17	3	3	29	31	4	86	97	2	23	33
TOTAL INCREASE		5,553	1,821	889	2,930	4,493	1,887	753	5,202	1,618	1,062	448
PERCENT INCREASE		43	58	44	80	55	95	53	139	159	106	39

For each watershed, table IV-17 shows natural sediment yield and the contribution of each management category. The total man-caused sediment is shown and expressed as a percent increase above natural sediment.

A chief concern of increased sediment is its effect on quality of aquatic habitat. Risk to habitat quality is rated as minimal for increases of 0-100 percent, low for 100-200 percent, medium for 200-300 percent, high for 300-400 percent, and extreme for increases greater than 400 percent (Alexander and Hansen 1986; Heller, Maxwell, and Parsons 1983; Stowell and others 1983). These risk classes are based on studies in the Great Lakes, Pacific Northwest, and Rocky Mountains areas, so they should be used with caution in the absence of local data.

Table IV-17 shows that for 8 watersheds, risk to aquatic habitat from sediment is minimal. Increases are especially small on watersheds with little private land and relatively low road density. Most of the increased sediment comes from the existing network of open roads which erode chronically year after year.

Risk is low in Indian Creek and Barren Fork in the Kentucky Basin and Stony Creek in the Cumberland Mountains. In all 3 watersheds, most of the increased sediment is caused by rather high road densities (over 1.5 miles per square mile) affecting streams with low natural sediment yields. In addition, Indian Creek has sizeable logging and grazing activities on private land. Vegetation management accounts for 0-2 percent of the total increased sediment and does not worsen risk to aquatic habitat or biota in any watershed.

7. Data Gaps

Data are lacking that isolate effects of vegetation management on channel sediment in the South. Effects on stormflows have been studied, but channel sediment has seldom been isolated from surface-eroded sediment. Channel sediment makes up a significant share of total sediment load, so data on how management affects it are important. The Council on Environmental Quality (CEQ) has prescribed a process for evaluating incomplete and unavailable information (40 CFR 1502.22).

To provide complete information, timber harvest and vegetation management activities must be studied on an array of landtypes in the South. Studies must be strictly controlled to isolate channel sediment due to increased stormflows from sediment due to surface erosion. Such a research program would be very difficult to implement, cost several hundred thousand dollars, and require 10 years or more. The Forest Service views these costs as too high to justify delay of this EIS.

CEQ regulations require that existing credible evidence be summarized and impacts be evaluated using accepted methods. Existing studies where surface erosion was essentially absent suggest that channel sediment typically increases roughly in proportion to peak flow. The processes involved are well understood but complex, so we have expressed percent increase in channel sediment as equal to percent increase in peak flow for ease of explanation. For example, chopping increases peak flow an average of 40 percent and so is estimated to increase channel sediment by 40 percent.

H. AIR QUALITY

Air is a dynamic resource whose quality fluctuates over time and space. Key air quality concerns are concentrations of gases and particulates that may impair human health and welfare. Prescribed fire is the only vegetation management method that emits substantial amounts of gases and particulates to the atmosphere. Prescribed fire presently occurs on about 10 percent of national forests in the Appalachians each year. On a given site, slash burns may occur once every 50-120 years and underburns every 3-9 years. Effects on air quality are brief and intermittent in each area affected.

Periodic fires have heavily influenced Appalachian forests. Loblolly, shortleaf, Virginia, pitch, and table mountain pine are fire-dependent subclimax species that are naturally succeeded by hardwoods in the absence of fire. These pines and some hardwoods, such as fire cherry, yellow poplar, and some upland oaks, have adapted to periodic burning regimes (appendix E). The air quality of the Appalachians has thus been subject to the influence of wildland fires for thousands of years.

Wildfires emit the same pollutants as prescribed fires. In general, emissions from wildfires are greater per acre burned and often occur at times when winds may carry smoke directly into sensitive areas. Smoke dispersion is also impaired when wildfires burn into the night (Sandberg and Ward 1981).

Any wildland fire burns in 4 phases (McMahon 1983; National Wildfire Coordinating Group 1985; Sandberg and others 1979). During preignition, fuels ahead of the fire are heated and dried and gases are released. During flaming combustion, temperatures rise rapidly, gases are flamed, and black smoke dominated by solid soot particles is produced. During smoldering combustion, temperatures drop and gases condense to produce white smoke composed mostly of liquid tar droplets. Smoldering emits 2-5 times the particulates as flaming. During glowing combustion, all combustible gases have been driven off, no visible smoke is produced, and carbon monoxide and carbon dioxide are the chief emissions.

1. Gases

EPA considers some gases emitted by prescribed fire (carbon monoxide, hydrocarbons, nitrogen and sulfur oxides, and photochemical oxidants) to be pollutants (McMahon 1981). Emission of these gases by prescribed fire, summarized by McMahon (1983), National Wildfire Coordinating Group (1985), Sandberg and Ward (1981), Sandberg and others (1979), USDA Forest Service (1976), and Van Lear and Johnson (1983), is discussed below. Added health risk to workers and the public from burning herbicide-treated versus non-treated vegetation is negligible (McMahon 1989).

Carbon Monoxide

This colorless, odorless, toxic gas is the most abundant air pollutant from forest fires. Its adverse effect on human health depends on exposure time, level of physical exertion, and concentration of gas. Typical emission factors range from 40 lb per ton of fuel consumed during flaming, to 200 lb/ton during smoldering, to 500 lb/ton in smoldering slash piles and organic soil. Concentrations may be 100-200 ppm at the fireline but diluted to less than 10 ppm about 100 feet downwind, so public health hazards are negligible.

Hydrocarbons

Hydrocarbons contain hydrogen, carbon, and sometimes oxygen. Typical emission factors are 30-100 lb/ton of fuel consumed, with most produced during smoldering. Most hydrocarbons have no harmful effect, but several, called polycyclic organic matter (POM), are carcinogens. These substances are produced by burning any carbon-based fuel. Forest fires account for only 3 percent of the national POM total (Anonymous 1984). Risk of developing cancer due to POM from prescribed fire is estimated to be less than 1 in a million (Dost 1986).

Nitrogen Oxides

At high concentrations, these toxic gases can affect the lungs. Prescribed fires emit only minor amounts by oxidation of fuel nitrogen. Most forest fuels contain less than 1 percent nitrogen, of which 20 percent is converted to nitrogen oxides when burned. Concentrations are not high enough to affect human health.

Sulfur Oxides

Emissions of sulfur oxides are negligible because most forest fuels contain less than 0.2 percent sulfur. Emission factors for woody fuels are less than 0.4 lb/ton. Risk of adverse effects on human health is minimal.

Photochemical Oxidants

Ozone can form in the upper layer of smoke plumes exposed to sunlight. Concentrations of up to 0.1 ppm have been reached in some plumes, usually in the first hour and within 2 miles downwind. Formation of photochemical oxidants by prescribed fire is a minor problem due to its intermittent occurrence.

2. Particulate Matter

Particulate matter, a complex mixture of solid and liquid particles, makes up the visible smoke seen in all fires. Particles 0.3-0.8 micron in diameter absorb and scatter light most efficiently. Those less than 10 microns in diameter can be inhaled. Those less than 2.5 microns in diameter can be breathed into the lungs. The average particle diameter in forest fire smoke is 0.1-0.3 micron; 90 percent of particles are less than 2.5 microns and nearly all are less than 5 microns (McMahon 1983; Sandberg and Ward 1981; Sandberg and others 1979; Van Lear and Johnson 1983).

Effects of particulates on air quality are analyzed here in 3 phases. Local effects are those felt near the burn. General effects are those felt over an area downwind from the burn. Regional effects are the cumulative effects of particulate emissions over the whole Appalachian Mountains.

Air Quality Standards

EPA has developed air quality standards for particulates to protect public health from respiratory damage and public welfare from impaired visibility and transportation hazards. The new PM_{10} standard applies to particulates less than 10 microns in diameter. It is exceeded if PM_{10} concentrations exceed an average of 150 micrograms per cubic meter (ug/m^3) for more than one 24-hour period per year, or an average of 50 ug/m^3 for an entire year (Stonefield 1987).

In addition to these general air quality standards, the Clean Air Act mandates special protection for visibility in Class I areas. There are 10 Class I areas in the southern Appalachians (table III-8). The basic strategy is to limit the total effect from all sources to less than a specified increase above a chosen baseline concentration. EPA may soon develop a $PM_{2.5}$ standard, for particulates less than 2.5 microns in diameter, which may have more impact on preserving visibility in Class I areas (Stonefield 1987).

In general, the states have responsibility for monitoring and enforcing air quality standards. National forests must comply with state regulations as well as our own smoke management guidelines.

Local Effects

In the South, the major effects of smoke on air quality are visibility reduction and respiratory impairment near the fire, especially on highways, at airports, and in populated areas. Particulate concentrations may meet the 24-hour standard of 150 ug/m^3 but exceed it by 10-fold or more for short periods. Personal exposure to such effects should occur only once every few years at most. This phenomenon is widely recognized, and research efforts have been organized to help control any temporary problems it might cause.

During flaming, smoke rises in a smoke plume. During smoldering, heat release is not enough to sustain plume rise so smoke stays near the ground. Ground smoke may worsen during inversions or in stable night air when rising humidity can cause a smoke-fog mixture to form. This problem can be especially acute in river valleys. Use of smoke management guidelines mitigates impacts by enhancing flaming, reducing smoldering, and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; McMahon 1983; National Wildfire Coordinating Group 1985; Paul, Lavdas, and Wells 1987; Petersen and Lavdas 1986).

Flaming is enhanced by using backing and flanking fires, which move slowly enough to preheat fuels and create a more uniform flame zone to consume gases. Smoldering is reduced by burning when large fuels are moist and unavailable and small fuels are dry, by broadcast burning slash rather than in piles (or at least keeping soil out of piles), and by promptly mopping up after the burn (McMahon 1983; National Wildfire Coordinating Group 1985; Pyne 1984; Sandberg and Ward 1981).

A slightly unstable atmosphere favors smoke dispersion. Such conditions are often characterized by good visibility, cumulus clouds, clear days, steady winds, and low to moderate humidity. Burning during downslope winds or high humidities should generally be avoided (National Wildfire Coordinating Group 1985; Paul, Lavdas, and Wells 1987).

General Effects

Smoke can impair general air quality in sensitive areas downwind from extensive burning. Use of smoke management guidelines mitigates impacts by reducing smoke emissions and burning during atmospheric conditions that favor smoke dispersion (Lavdas 1986; Petersen and Lavdas 1986; Sandberg 1983; USDA Forest Service 1976). Following is a discussion of smoke emission and dispersion principles.

SMOKE EMISSIONS are a product of emission factor (pounds of particulates produced per ton of fuel consumed) and amount of fuel consumed. Emissions are reduced by increasing combustion efficiency, which is highest during flaming and when small fuels are homogeneous, loose, and dry. Backing and flanking fires produce one-third of the smoke that head fires do. Mass-igniting slash burns, which reduces buildup time to flaming, can reduce emissions of a fire under ideal conditions by up to 25 percent. Broadcast burning slash rather than in piles (or at least keeping soil out of piles) greatly reduces smoldering (Sandberg 1983; Sandberg and Ward 1981; Sandberg and others 1979).

Emissions are also reduced by limiting fuel consumption. Slash burning when duff and large fuels are moist and unavailable limits smoldering and can reduce emissions of a fire under ideal conditions by up to 50 percent. This strategy is accomplished by scheduling slash burns soon after a soaking (0.5 inch or more) rain. Emissions from smoldering are also reduced by promptly mopping up after a burn (National Wildfire Coordinating Group 1985; Sandberg 1983, 1985; Sandberg and Ward 1981).

ATMOSPHERIC DISPERSION can lessen general effects through two smoke management strategies. "Avoidance" uses wind direction to send smoke away from sensitive areas. "Dilution" uses favorable weather conditions to reduce concentrations of smoke in sensitive areas downwind (Sandberg 1983).

Avoidance is most appropriate for reducing impacts to nearby areas by sending smoke away from them. To be successful, variations in wind direction over time and space must be considered. Because predicting wind direction is difficult for more than 24 hours, during light winds, and at night, avoidance is not usually appropriate for long-duration fires or fires that smolder into the evening.

Dilution relies on mixing smoke with clean air vertically and horizontally. Atmospheric stability, mixing height, and transport windspeed govern this process (National Wildfire Coordinating Group 1985; Pyne 1984; USDA Forest Service 1976).

Atmospheric stability affects rate of smoke dispersion. An unstable atmosphere is turbulent and rapidly mixes smoke. Slight instability usually provides adequate smoke dispersion but maintains a steady enough wind for good fire control. A neutral atmosphere may provide adequate dispersion, depending on other atmospheric factors.

Mixing height also affects rate of smoke dispersion. It is the vertical extent of unstable air, capped by an inversion or windshear layer, that allows vertical spread of a smoke plume through convection and turbulence. High mixing heights mean large volumes of air may be available for smoke dispersion. To provide adequate dispersion, mixing heights should exceed 1,600 feet. Lower mixing heights are most common under low inversions and windshear layers, under stagnant high pressure systems, and on the cold air side of warm, stationary, or weak cold fronts. On generally clear nights with light winds when surface temperature inversions form, there is no mixing height and smoke is trapped near the ground and spreads very slowly.

Transport windspeed is the average windspeed within the mixing height, the layer of air likely to contain smoke. Adequate smoke dispersion requires a transport windspeed of at least 9 mph.

Combinations of atmospheric stability, mixing height, and transport windspeed needed for good smoke dispersion are most common between high and low pressure systems and behind vigorous cold fronts. The combined effects of atmospheric stability, mixing height, and transport windspeed on smoke dispersion have been expressed in a numerical rating called the "dispersion index" (Lavdas 1986).

Regional Effects

Regional effects on air quality are analyzed as the cumulative smoke emissions of all prescribed fires and wildfires on all lands in the Appalachian Mountains. Prescribed fire accounts for 17 percent of emissions from wildland fires in the South (Sandberg and others 1979). Even in alternative H, prescribed fires on national forests total 61,200 acres per year, only 8 percent of all prescribed fire acres in the area. National forest prescribed fires should thus account for less than 2 percent of smoke emissions from wildland fires (0.17 x 0.08) and have negligible effects on regional air quality.

Other regional and global concerns are acid deposition, the greenhouse effect, and ozone impacts. Prescribed fires emit relatively minor amounts of organic acids and nitrogen and sulfur oxides to the atmosphere, so their impact on acid deposition is negligible. They also release calcium and magnesium to air and soil, so they may actually reduce acid deposition locally (appendix B).

The greenhouse effect depends on the balance between global outputs of oxygen and carbon dioxide. The ozone layer is affected by global outputs of ozone-depleting compounds that reach the upper atmosphere. Wildland fires emit large amounts of carbon dioxide and smaller amounts of other "greenhouse" gases. They also emit compounds that can act as precursors for both ozone production and depletion. But forestry prescribed fires emit tiny amounts of such gases compared to other forms of biomass burning. All prescribed fires in all temperate forests of the world are estimated to account for only 0.1-0.4 percent of the global biomass burned annually (Seiler and Crutzen 1980).

3. Emission Estimates

Effects of the alternatives on air quality are analyzed by estimating total smoke emissions from prescribed fires and wildfires on national forests. Emissions are a product of emission factors, fuel loads, and acres burned in each of three major fuel groups:

a. Grass--mountaintop balds in the Unaka and Blue Ridge mountains.

b. Heavy brush--pine/rhododendron-laurel fuel type.

c. Light brush--pine and pine-hardwood fuel types (including hardwood type when prescribe burned).

Emission factors vary by fuel consumed and combustion mode. Available fuels include grass in grass burns, plus litter and brush in underburns, plus tree limbs and foliage in slash burns and wildfires. Smoldering increases emission factors, which are typically 15 lb/ton for grass burns, 35 lb/ton for heavy brush underburns, 75 lb/ton for light brush underburns and slash burns, and 100 lb/ton for forest wildfires (McMahon 1983; Sandberg 1983; USDA Forest Service 1976; Ward 1983).

Available fuel load depends on fuel type, buildup, arrangement, and moisture content. Typical available fuel loads for underburns are 3-4 tons/ac in grass and light brush fuels and 4-6 tons/ac in heavy brush fuels (Mutz and others 1985; Sackett 1975; USDA Forest Service 1976). Wildfires in underburned stands consume 1 ton more than underburns because they tend to burn under drier conditions. If underburns are excluded, available fuel for wildfires can eventually build up to 8-10 tons/ac in grass and light brush fuels and 18-22 tons/ac in heavy brush fuels (USDA Forest Service 1976).

Underburns interrupt fuel buildups, slowing the spread and aiding the control of wildfires. Excluding underburns in large tracts of heavy brush fuels may increase average acres burned by wildfire by up to 100-fold (Davis and Cooper 1963). In the Appalachians, however, variations in topography confine heavy brush fuels to scattered stands. Underburns in hardwoods probably do not reduce wildfire acres significantly. Excluding underburns should increase wildfire acres only in large tracts of light brush fuels under pine or pine-hardwood overstories, by perhaps five times. Such tracts occur almost solely on rather flat terrain in the Cumberland Plateau.

In each alternative, the acres burned by prescribed fire and wildfire are multiplied by the emission factors and fuel loads discussed above to estimate total smoke emissions from each fuel group. Slash burns occur almost solely in pine and pine-hardwood stands and underburns mostly in light brush fuels under pine and pine-hardwood overstories. Grass burns are confined to mountaintop balds. See section IV.N. (Summary of Impacts by Alternatives) for smoke emission estimates.

I. WILDFIRE

Periodic fires have heavily influenced Appalachian forests. Most pines are fire-dependent and some hardwoods are specially adapted to fire. Prescribed fire can affect the occurrence and spread of wildfires.

scaped Prescribed

Prescribed fires can become wildfires when they accidentally escape their boundaries and burn adjacent areas. These effects are mitigated by burning under fuel and weather conditions that promote control of fire spread. In general, escaped prescribed fires are quickly controlled, so their effects are minimal.

uel Reduction

Underburns slow the spread and aid the control of wildfires by interrupting fuel buildup beneath pine and pine-hardwood overstories. When underburns are excluded in such fuel types, fire hazard increases progressively as litter accumulates, flammable understory shrubs increase in size, and needle drape develops, providing a pathway for surface fire to reach tree crowns (Wade 1983).

Unless reduced by underburns, fuels build up beneath pine stands until an equilibrium is reached between accumulation and decomposition (Wade 1983). Litter fuels reach equilibrium in 5-10 years (Sackett 1975), but time to total fuel equilibrium may take several decades (Wade 1983).

Available fuels in underburned stands amount to 3-6 tons per acre (USDA Forest Service 1976). If underburns are excluded, available fuels for wildfires can build to 8-10 tons per acre in grass and light brush fuel groups and 18-22 tons per acre in heavy brush fuels (Martin and others 1979; USDA Forest Service 1976). Hazards are highest in rhododendron-laurel understories, which are very flammable and can grow to six feet, forming an effective "ladder" to the canopy (USDA Forest Service 1976).

Underburns done in cycles longer than 9 years can damage the overstory and be harder to control. Excluding underburns in large tracts of light brush fuels under pine or pine-hardwood overstories may increase average acres burned by wildfire by 5-fold. Over time, increased recreation use of national forests should increase risk of wildfire occurrence.

Prescribed fires also decrease wildfire hazard on adjacent lands. Excluding underburns increases spread of wildfire from national forests to these lands. Over time, increased urbanization should increase wildfire hazard to people and property.

ISUAL QUALITY

ntroduction

Of all landscape elements, vegetation is the most significant visual feature and is the element most readily manipulated. Manipulation intensity and timing affect the significance of impact on visual quality. A favorable climate and vegetation variety allow vegetation to recover quickly after most treatments. In assessing effects of treatments in each alternative, it is assumed that management requirements and mitigation measures (chapter II) are employed. Also assumed is that visual quality objectives for treatment areas are met, except for alternatives A and H. Variables that affect scenic quality are treatment type, number of acres treated, slope, and duration of effect, visibility and season of year.

1. Effects of Prescribed Fire

Prescribed fire temporarily reduces understory vegetation and can maintain open forested conditions with more opportunity for views and vistas. Reduction of underbrush creates better pedestrian access. Periodic fire also promotes numerous flowering plants.

Understory burns create a charred appearance on tree trunks, lower limbs, and forest floor that lasts 3 to 4 months. With more intense burns and in hot spots, more of the tree is charred and often tree-crown scorch occurs. Site preparation burns create a charred appearance over broader landscape areas with few vertical breaks, but these effects are diminished quickly as new sprouts turn the area green. The effect can last 3-5 years or more. Smoke accumulations on relatively calm days reduces visibility in downwind areas and in valley bottoms. Windier days disperse smoke faster and keeps visibility higher, but may affect larger areas.

Repeated treatments of fire in the same area can reduce understory species and maintain side spacing between trees. On rights-of-way variety changes from tall trees to shrubs, herbs, and grasses; however, the number of plants increases considerably. The vegetation mix remains dynamic and fluctuates with treatments. These changes create a variety of wildflowers, flowering shrubs, grasses, and other plants (Bramble and Byrnes 1982).

2. Effects of Mechanical Methods

Mechanical methods can expose soils and generally reduce vegetation to ground level or less than 3 feet high. Considerable seasonal browning occurs and broken stems create an unsightly landscape. Raking and piling leave debris that may be visible 3 to 4 years before being obscured by new growth, unless the windrows or piles are burned. Mechanical treatments also reduce shading vegetation and allow more wildflowers and other sun-tolerant plants to come into the area until trees and shrubs shade or crowd them out.

3. Effects of Manual Methods

Manual treatments leave browned slash and a graying appearance for a season to a year. Regrowth and residual vegetation obscure the effect within a few months. Canopy heights are reduced, but species variety is generally maintained.

4. Effects of Herbicides

Herbicide treatments reduce variety by eliminating target species, but the space is usually filled quickly by lower-growing shrubs, grasses, or herbs. Herbicide treatments also create a browning and then a graying that can last from a season to several years depending on the treated vegetation's height and the herbicide's persistence. For example, stem injection of large stems produces a very long-lasting effect. Frequent treatments such as those on rights-of-way have less lasting visual effects. Broadcast applications create a stronger visual effect than more selective ones. Hand applications generally create irregular or spot patterns of brown and gray. Less total area receives treatment due to the selective application.

5. Effects of Biological

The light to moderate grazing used on balds has a negligible effect on visual quality.

K. RECREATION

Since Appalachian Forests provide nearly 15 million recreation visitor days annually (chapter III) large numbers of people are potentially affected by vegetation control done to improve or enhance their experience. Generally, vegetation control for recreation purposes is used to protect health and safety, provide comfort, protect investments, or improve appearances. Conversely a lack of control or improper application has negative effects on recreation user's experiences.

Vegetation control for recreation purposes varies little between alternatives except for alternative A which does not allow treatments and alternative F which uses no herbicides. Other alternatives use various amounts of manual, mechanical, and herbicide treatments. Fire and biological methods normally are not used in recreation sites.

Manual and mechanical treatments usually leave brown slash. Possible negative effects from not doing or limiting vegetation control are: deterioration of facilities including roads, trails, parking lots, and buildings; increased exposure to noxious or toxic plants for workers and users; obstruction of vistas; threats to safety, such as hazard trees; and decreased access.

L. CULTURAL RESOURCES

Effects on cultural resources are associated with activities that cause soil disturbance, particularly mechanical treatments, but may also be directly associated with prescribed or wildfires.

Effects of mechanical treatments increase as depth of penetration into soil or movement of soil from one place to another increases. For example, mowing and shearing do not penetrate soil, but such tools as ripping and disking do. Effects from fire are generally limited to those resources on or above ground such as buildings.

Vegetation management should not be viewed as a single, isolated activity, but rather as one element of a broader resource management program. Thus, roads, trails, powerlines and pipelines may already have been built and timber may have been harvested. These activities can cause substantial soil disturbance without vegetation management.

Each cultural resource is a piece of a puzzle that tells us about earlier societies. Loss or damage of a single artifact may limit our knowledge and understanding of earlier societies, but this loss may not always be critical. As more artifacts are lost, however, interpretation becomes increasingly difficult. Related to this cumulative loss is the fact that cultural resources are afforded greater protection on Federal lands than on others. Loss or damage of cultural resources on other lands could increase the significance of such resources on Federal lands.

M. SOCIOECONOMIC CONDITIONS

People who live, work, or visit in or near Appalachian national forests are affected by vegetation management. Generally, however, these effects are dwarfed by the magnitude of other local, national or even global trends.

1. Effects on People's Expectations

People's expectations cover the range from primitive to rural (chapter III). Vegetation management enhances the ability of forests to meet some expectations and detracts from the ability to meet others. Factors that adversely affect experience quality would generally have more negative impacts on neighbors/newcomers and visitors than on workers/long-term residents. Factors that affect jobs and employment would have more effect on workers/long-term residents. Magnitude of these effects would influence the amount of social conflict that might occur if various alternatives were implemented.

2. Effects on Employment

Despite more substantial influences from regional or national trends, rural communities depend heavily on agriculture/forestry and related services. Employment relates to labor intensity of the practices used (Watson, Straka, and Bullard 1987). Though this study is based on Coastal Plain and Piedmont work activities, it has reasonable labor component data for the Appalachian Mountains. The total labor component, including supervision and overhead, for each method is:

*Method	Percent Labor
Mechanical	39
Prescribed Fire (Ground)	67
Prescribed Fire (Aerial)	49
Herbicide (Ground)	26
Herbicide (Aerial)	17
Manual	92

*Biological data are not included in this study, but herd management (labor) represents a small component.

Manual methods provide the most employment, but the difference between alternatives averages less than one job per county. Total program cost affects employment more; lower-cost alternatives generally provide less employment. In our analysis, mix of methods and program cost are both considered to assess effects on employment.

3. Effects on Civil Rights

In every alternative, effects on civil rights, including those of minorities and women, will be statistically insignificant and unplanned. Analysis of possible effects occurs in the site-specific environmental analysis or during project design. The following topics are of concern:

- Risks to worker health and safety because racial and cultural minority groups may represent a large fraction of this work force;
- Employment opportunities and representation in the work force for minorities and women.

4. Effects on Outputs and Costs

Some outputs are generated at the expense of others, or output levels may change with intensity of treatment. Additionally, costs for conducting vegetation management vary. Some treatments are long-lasting while others must be repeated. Some require little labor or equipment and others require much.

Production of outputs in many cases requires vegetation management. Each multiple use including forage, recreation, water, wildlife, and wood is affected. Conversely, lack of treatment is sometimes essential for these outputs. For example, vegetation management is done to retain or improve vistas for road tours, but little is done in a primitive setting where a closeness to nature is desired. Each is a recreation output and each requires different treatment.

Information on activity cost, acres, method of treatment, and purpose was collected from all Appalachian forests for work done during fiscal years 1986 and 1987. These figures represent an expenditure of $7.0 million (labor, materials, handling, equipment, supervision) on 131,080 acres. Average costs by method and tool are shown in table IV-18.

Average costs by activity are:

Activity	Average Cost/Acre
Site Preparation (Pine)	$61.49
*Site Preparation (Hardwoood)	71.25
Timber Stand Improvement (Pine)	65.81
*Timber Stand Improvement (Hardwood)	60.30
Wildlife Habitat Improvement	14.54
Wildlife Openings Maintenance	112.88
Corridor Maintenance	27.01
Range Forage Maintenance	16.94
Fuels Treatment	12.06

*Data not available on other purposes, assumed to be somewhat higher than in pine management.

Vegetation management may change the amount of money passing through the economy, particularly in the form of wages and 25-percent returns to county governments. It may also change indirect costs and opportunity costs. For instance, action or lack of action at the right time and place results in later costs or loss of subsequent benefits. Local or area economics and social structures adjust over the long term to reflect labor force needs, services, and money flowing through the community. Both supply and demand tend to adjust toward equilibrium.

N. SUMMARY OF IMPACTS BY ALTERNATIVES

This section displays overall environmental effects of each alternative. A capsule of the alternative's program is followed by an element-by-element discussion of environmental effects. This section forms the basis for the comparison of alternatives in sections II.G and II.H.

Table IV-18.--Vegetation management costs per acre by method, Appalachian Mountains

Vegetation Management Method	-----Per Acre Cost-----	Average Cost/Acre
Herbicide		77.59
Aerial tools		
Helicopter		
Utility ROW	120.00	
Site Preparation	68.41	
Release	55.19	
Mechanical ground tools		
Boom sprayers	81.18	
Granular spreader	78.56	
Utility ROW	160.00	
Hand tools		
Backpack sprayers	68.41	
Spotgun	74.32	
Hypo-hatchet	88.35	
Injectors	61.14	
Hack & Squirt	103.98	
Backpack sprayers/injectors	64.78	
Utility ROW	210.00	
Manual		71.56
Power tools		
Chainsaws	64.61	
Brushcutters	89.04	
Hand tools		
Axe	74.34	
Brushhook	58.26	
Utility ROW		
Less than 30% slope	360.00	
More than 30% slope	450.00	
echanical		86.12
Scarifying tools	95.50	
Shearing tools	147.04	
Disking tools	64.35	
Mowing tools	37.60	
Shearing/crushing	106.35	
Shearing/piling, raking	130.70	
Utility ROW (where slope allows)	95.00	
rescribed Fire		11.02
Aerial ignition devices	3.85	
Helitorch	14.50	
Drip, drag torches	14.71	
ological - No data		

Alternative A

This is the "no action" alternative. Vegetation management is not done. Existing vegetation is allowed to grow without manipulation.

Human Health and Safety

There are no direct effects on human health or safety from vegetation management. However, management of rights-of-way becomes ineffective, resulting in a decrease in safety of these facilities. Increased fuel loads throughout the forest lead to an increased risk and intensity of wildfire, increasing risk to persons and properties adjacent to these untreated lands. Risk of serious injury is expected to result to firefighters and to neighbors and visitors as a result of the increase in frequency and severity of wildfires. Trails and recreation areas deteriorate; vegetation is not managed to protect visitor safety even in designated recreation areas, and serious visitor accidents occur more frequently than at the present time.

Vegetation

Succession following timber harvest proceeds uninterrupted except for natural occurrences such as wildfires, tornadoes, and ice and snow damage. Complete regeneration failures, as well as marginal survival and loss of growth and form occur for both natural and planted pine and hardwood species on harvested areas with vigorous competing vegetation. Herbaceous species gradually decline. Shade-tolerant woody species gradually replace shade-intolerant species in the midstory and overstory.

Wildfires occurring during dry weather in accumulations of hazardous fuels are of high intensity, causing significant injury and mortality to vegetation. Greater mortality of woody vegetation occurs during the growing season.

On mountaintop balds herbaceous species are gradually replaced by woody species such as blackberries, hawthornes, and rhododendron. Tree species such as spruce, fir, beech, sugar maple, red maple, and buckeye gradually encroach from the edges of the balds.

Wildlife

Prescribed fire and other treatments are unavailable for improving habitat for any species. Because intermediate treatments are not done, regeneration areas rapidly lose their value for species like deer as forage and browse production declines.

Increased wildfires create some habitat for early successional species but destroy habitat for mid to late successional species such as brown-headed nuthatch (*Sitta pusilla*) and pileated woodpecker (*Hylatomus pileatus*). Species such as grey squirrel benefit from hardmast production, but many species are affected adversely by low amounts of soft mast and forage production.

Wildlife openings and rights-of-way lose their value as feeding and nesting areas for species like turkey and rabbits as woody vegetation encroaches. Since no vegetation management is done, few downed logs are created for sunning sites for reptiles or cover for amphibians, and few snags are created for raptors or cavity-nesting birds.

Threatened, Endangered, Proposed, and Sensitive Species

Lack of vegetation management, particularly prescribed fire, prevents management of habitat for any species. Habitat is improved for some species but destroyed for others by high intensity wildfires. Many species, especially fire-dependent species like the red-cockaded woodpecker and Biltmore sedge, decline. Although extinction is improbable as long as populations exist on state or private lands, recovery becomes unlikely as habitat suitability declines.

Soil

Fire protection plus lack of underburns allows wildfire hazard to increase in some fuel types through progressive fuel buildup. Wildfires are estimated to burn about 30 percent more acres than at present. Some of these acres are severely burned, resulting in impaired soil productivity.

Water and Aquatic Life

The increase in severe wildfires mentioned above increases stormflows and sediment yields in some areas.

Wildfire and Air Quality

Prescribed fire is not used, so wildfires are estimated to increase to at least 10,400 acres per year and are more intense in some fuel types. Annual smoke emissions from national forests are estimated at 6,100 tons per year, all from wildfires.

Visual Quality

Lack of treatment allows vegetation to encroach on views and vistas. Open, parklike areas eventually disappear with encroachment of midstory and understory vegetation. Wildfires are more intense, which increases mortality and creates a negative visual effect.

Recreation

Lack of vegetation control creates increasing exposure to recreationists from noxious weeds and toxic plants resulting in a higher potential for exposing visitors to minor health problems. Trees and other plants invade trails, parking lots, roads, vistas and recreation sites. This reduces the functional utility and investment value of these sites and facilities. Hazardous trees would remain in recreation sites and increase risk of accidental injury or death.

Cultural Resources

Risk of damage to cultural resources is low because no treatments are allowed. There is an increased risk of damage from wildfires in some fuel types.

Socioeconomic Conditions

Alternative A directly benefits those who enjoy a primitive forest setting, and negatively affects those who enjoy more rural settings. Social conflict is expected because of the magnitude of the change from current actions, and the perception that one group is receiving most benefits while another is suffering most losses. Employment opportunities and direct costs are lowest. Output of managed resources declines substantially.

Alternative B

Vegetation management is restricted to treatments that achieve minimum resource objectives. Minimum risk herbicides are applied only by hand. Only low disturbance mechanical tools and low intensity prescribed fire are used. Projected acres treated per year total 53,776.

Human Health and Safety

The limitations placed on the overall vegetation management program allows for the maintenance of minimal health and safety standards. Roadsides and utility rights-of-way are maintained to a lower standard than at present, but safety is emphasized and no significant deterioration occurs. Forest condition is not a primary concern. Safety is a major criterion in determining the need for vegetation management in general forest areas.

The restriction to use only manual (primarily backpack) methods of herbicide application poses the greatest risk per hour of worker exposure, but the limited acreage treated moderates overall worker risk. Additional mitigation measures required (chapter II) beyond current practice should further reduce potential worker risk. Broadcast application of herbicides is greatly reduced by the manual tool requirement (although backpack sprayers can be used to produce a treatment which is broadcast). Public safety is unaffected; the choice of manual tools results in virtually no potential to expose the public to herbicides.

Limited use of prescribed fire causes a low number of accidents during prescribed burning operations. Risk to workers from manual and mechanical tools decrease based on the size of the program. Risk to the public is virtually unchanged since treatments will be applied to areas in direct relation to use; highest use areas will have highest public priority for treatment.

Vegetation

Selective application of herbicides to a projected 6,005 acres results in minimal loss of non-target plants.

Prescribed burning for fuel reduction projected to occur on a 7-year cycle marginally controls the buildup of hazardous fuels. Low intensity dormant season burns at this cycle produce a mix of woody and herbaceous species with a greater number of woody species growing into the understory and midstory. Herbaceous species decrease in number.

Mechanical tools causing only low soil disturbance are used. Herbaceous species initially increase, then after approximately 3 years begin to decline. Woody species initially decline but most recover within 5 years. Mortality of woody species due to uprooting is very low.

On manually treated areas repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems.

On grassy balds, dormant season prescribed burning projected to occur every 4 years marginally controls woody species encroachment, but may enhance the spread of species such as blackberries. Those grassy balds with existing moderate to high levels of woody species encroachment will not be able to be maintained in a grass-stage community by only dormant season fires at a 4-year cycle. Selective herbicide treatment; and grazing or mowing after a late dormant season burn may enhance woody species control. Grazing and/or mowing after initial spring growth also enhances the control of woody species.

Wildlife

Effects are similar to alternative A, but fire-dependent species benefit more since over 10,000 acres of prescribed burning for wildlife and T&E species occurs. Maintained rights-of-way produce habitat and some "edge" for species like rabbits.

Threatened, Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protection populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years in habitat for threatened and endangered species; 4 years on balds; 5 years in other wildlife habitat; and 7 years for fuel reduction. Slash burns occur on a projected 1,387 acres per year and are estimated to be 70 percent light and 30 percent moderate. Piling and raking are not used.

Moderate slash burns and 3-4 year underburns pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 258 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 3,832 acres per year). Treatment intensity is low, producing about 110 tons of sediment per year; this is less than 0.1 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 1,387 acres, underburns on 20,479 acres, grass burns on 559 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 3,200 tons from prescribed fire and 4,700 tons from wildfire, for a total of 7,900 tons.

Visual Quality

Visual impacts are minimal and activities are performed to meet established visual-quality objectives. Some vistas and open parklike stands may be closed due to limited treatments.

Recreation

Some safety hazards exist due to limited vegetation control in recreation sites. Highest hazards such as defective trees in campgrounds are treated while lesser hazards are allowed to remain. Considerable risk to recreationists from exposure to toxic plants exist with the limited vegetation management. Prescribed burning may temporarily affects air quality and restricts visibility in some recreation areas.

Cultural Resources

The two methods with high risk, mechanical and fire, are utilized at acre levels and intensities substantially below current, so risk to cultural resources is quite low.

Socioeconomic Conditions

Alternative B primarily benefits those who enjoy primitive forest settings, and negatively affects those who enjoy more rural settings. Some social conflict is expected due to the change from current actions, and the perception that one group receives more benefits while another suffers more losses. Employment opportunities are lowest of all alternatives where management is done. Total cost is $1.65 million and per acre costs are $31.87. Managed outputs decline from present levels.

Alternative C

This alternative continues present levels of treatment specified in Forest Land and Resource Management Plans. Herbicides are applied by hand and machine. Mechanical tools cause low to high disturbance. Prescribed fire is of **low to high intensity.** Projected acres treated per year **total 130,045.**

Human Health and Safety

Herbicide application is permitted by all ground methods (manual or mechanical) and can be either broadcast or selective. Overall, ground application methods pose no significant risks of acute, sub-chronic, or chronic toxicity, nor do they pose significant cancer or mutagenicity risks to workers or the public. Exceptions (2,4-D, 2,4-DP, and tebuthiuron) are noted in the discussion of human health effects. Mitigation which would ensure that risk to workers and the public meet EPA's ecological risk standards for all evaluated herbicides and additives, is not considered beyond that currently in effect.

Of methods used, manual methods and prescribed fire pose the greatest (frequency and accident severity) risk to workers. Mechanical methods are responsible for very few accidents.

Vegetation

Choice of herbicide and application method allows either selective or broadcast treatments of granular and liquid herbicides by hand or mechanical ground methods. The use of broadcast treatments increases the risk of damage to non-target species. Herbicides are projected to be used on

24,494 acres. Temporary reduction of competing vegetation is achieved. Broadcast treatments increase herbaceous species and reduce woody species.

Prescribed burning for fuel reduction at a 6-year cycle adequately controls the buildup of hazardous fuels. Dormant season underburns at this cycle produce a mix of woody and herbaceous mid- and understory species. Where growing season burns are used (pine site preparation, for example) a greater number and variety of herbaceous species will be produced. Use of higher intensity fire in this alternative further reduces woody species and increases herbaceous species.

Mechanical tools causing low to high soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations produce a greater decline in woody species. Some mortality of woody species occurs through uprooting by raking and disking. Most woody species fully recover within 5 to 10 years following treatment.

Where manual methods are used, repeated treatments on sites with high numbers of competing stems are necessary in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems.

Prescribed burning on a 3-year cycle, as well as grazing, mowing, manual, and selective herbicide treatments, adequately maintains herbaceous species on grassy balds. Increased woody species control occurs with selective herbicide treatments and combination treatments such as early growing season burns followed by grazing or mowing.

Wildlife

The range of vegetation management tools in alternative C provides the widest variety of habitats and successional stages for the most species. Deer and turkey populations benefit from prescribed burning, opening maintenance, and other habitat improvement treatments. Mast producers are often not favored due to use of non-selective treatments. Snags for cavity nesters and downed logs for reptiles and amphibians are created.

Threatened, Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 6 years for fuel reduction. Slash burns occur on a projected 5,550 acres per year and are estimated to be

30 percent light, 50 percent moderate, and 20 percent severe. Piling and raking are projected to occur on only 107 and 27 acres per year, respectively.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Severe slash burns and raking pose high risk on good soils and extreme risk on fair and poor soils. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,800 acres, high on 64,680 acres, and extreme on 2,880 acres; 1.3 percent of the national forests are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 15,324 acres per year). Treatment intensity is low to high, producing about 1,510 tons of sediment per year; this is 0.9 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 5,550 acres, underburns on 38,263 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 7,100 tons from prescribed fire and 4,700 tons from wildfire, for a total of 11,800 tons.

Visual Quality

Visual impacts result mainly from prescribed fire, herbicide and mechanical methods. Visitors viewing treated areas see evidence of treatments up to 6 months, but degree of change meets retention to modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Vegetation management may affect the availability of recreation opportunities through temporary site closures to remove hazard trees, prescribe burn and spray toxic plants. Prescribed burning may temporarily affect air quality and restrict visibility around some recreation areas. Broadleaf plants and those which produce edible berries and fruit may be included as herbicide target species or be inadvertently sprayed and thereby lost for recreation opportunities.

Cultural Resources

Availability of high disturbance mechanical tools represents a relatively high potential for cultural resource damage on treated acres. Utilization of prescribed fire moderates possible effects from wildfire.

Socioeconomic Conditions

Alternative C provides some balance between those who enjoy a primitive or semi-primitive forest setting and those who enjoy more rural settings, though roaded--natural settings predominate. Some conflict exists at current levels. There is a high level of employment opportunity (though some alternatives have higher levels). Managed outputs are also relatively high. Per acre treatment costs average $54.76 and total costs are $6.97 million.

Alternative D

Use of manual and mechanical methods is reduced. Minimum risk herbicides are applied by hand, machine, and helicopter. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 130,045.

Human Health and Safety

Increased herbicide use slightly increases herbicide-related accidents, but decreased use of manual methods significantly decreases other accidents. The net effect is to improve worker safety from the current program. Due to the use of less risky herbicides at reduced rates per acre, overall risk to human health is about the same as in the current program.

Allowing aerial treatment of 900 acres of power and gas line rights-of-way does not result in risk of public exposure since the acres treated are expected to be clearly marked and located in remote areas. Neither drift nor public contact of treated vegetation should pose a risk.

Prescribed fire and mechanical methods pose approximately the same risks as disclosed for the current alternative.

Vegetation

Risk to non-target species from increased use of herbicides is more than offset by a reduction in broadcast treatments from present levels.

Prescribed burning for fuel reduction projected to occur on a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity dormant season underburns at this cycle produces a mix of woody and herbaceous mid- and understory species. Growing season burns for site preparation or bald maintenance produce a greater number and variety of herbaceous species.

Mechanical tools causing only low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline in woody species. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Where manual methods are used, some repeated treatments occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedling or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems.

Prescribed burning projected to occur on a 3-year cycle, as well as grazing, mowing, manual, and selective herbicide treatments adequately maintains herbaceous species on grassy balds. Additional woody species control occurs with increased selective herbicide treatments and combination treatments such as early growing season burns followed by grazing or mowing.

Wildlife

An increase in selective herbicide application increase hard and soft mast producers used by many animals including deer, turkey, and squirrel on some sites, but where broadcast methods are used, hard- and soft-mast producers are reduced. Low use of mechanical tools leaves snags for raptors but fewer downed logs for reptiles and amphibians.

Threatened, Endangered Proposed, and Sensitive Species

Prescribed fire, manual, and selective herbicide methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 6 years for fuel reduction. Slash burns occur on a projected 7,050 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is projected to occur on only about 90 acres per year and raking is not used.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 2,040 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 18,824 acres per year). Low to moderate treatment intensity produces about 590 tons of sediment per year; this is 0.3 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments on some utility lines pose some risk of accidental direct application of herbicides to streams.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 7,050 acres, underburns on 38,509 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 7,700 tons from prescribed fire and 4,700 tons from wildfire, for a total of 12,400 tons.

Visual

Visual impacts result mainly from prescribed fire, herbicide, and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Vegetation management may affect the availability of recreation opportunities through temporary site closures to remove hazard trees, prescribe burn and spray toxic plants. Prescribed burning may temporarily affect air quality and restrict visibility around some recreation areas. Broadleaf plants and those which produce edible berries and fruit may be included as herbicide target species or be inadvertently sprayed and thereby lost for recreation opportunities.

Cultural Resources

Reduced intensity and reduced acreage of mechanical treatments from Plan levels allows a moderate potential for cultural resource damage. Risk from fire is unchanged.

Socioeconomic Conditions

Alternative D provides primitive or semi-primitive forest settings as well as rural settings. Some social conflict occurs due to decreased use of manual and mechanical methods, and the possibility of aerial herbicide application. This conflict is moderated by the use of only low or moderate intensity prescribed burning, and limited aerial herbicide application. Employment opportunities are slightly lower than current. Managed output levels are unchanged, but per unit costs are slightly lower. Total cost of vegetation management is $6.87 million, per acre costs are $54.04.

Alternative MODIFIED D

This alternative modifies alternative D by reducing total herbicide use (shifting to more mowing, manual, and fire tools in roadsides, wildlife openings, and recreation sites) and broadcast (aerial and ground) herbicide treatments.

Human Health and Safety

Increased herbicide use slightly increases herbicide-related accidents from the present, but only half as much as in alternative D. Decreased use of manual methods significantly decreases other accidents, but not quite as much as in alternative D. The net effect is to slightly improve worker safety from the current program. Due to the use of less risky herbicides at reduced rates per acre, overall risk to human health is about the same as in the current program.

Allowing aerial treatment of only 400 acres of power line rights-of-way does not result in risk of public exposure since the acres treated are to be clearly marked and located in rugged, remote, and uninhabited areas. Neither drift nor public contact of treated vegetation should pose a risk.

Prescribed fire and mechanical methods pose approximately the same risks as disclosed for the current alternative.

Vegetation

Risk to non-target species from increased use of herbicides is more than offset by a reduction in broadcast treatments from present levels and even from alternative D.

Prescribed burning for fuel reduction projected to occur on a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity dormant season underburns at this cycle produces a mix of woody and herbaceous mid- and understory species. Growing season burns for site preparation or bald maintenance produce a greater number and variety of herbaceous species.

Mechanical tools causing only low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline in woody species. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Where manual methods are used, some repeated treatments occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedling or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems.

Prescribed burning projected to occur on a 3-year cycle, as well as grazing, mowing, manual, and selective herbicide treatments adequately maintains herbaceous species on grassy balds. Additional woody species control occurs with increased selective herbicide treatments and combination treatments such as early growing season burns followed by grazing or mowing.

Wildlife

Increased selective herbicide application increases hard and soft mast producers used by many animals including deer, turkey, and squirrel on some sites. Low use of mechanical tools leaves snags for raptors but fewer downed logs for reptiles and amphibians.

Threatened, Endangered Proposed, and Sensitive Species

Prescribed fire, manual, and selective herbicide methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 6 years for fuel reduction. Slash burns occur on a projected 7,050 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is projected to occur on only about 90 acres per year and raking is not used.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 2,040 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 18,824 acres per year). Low to moderate treatment intensity produces about 510 tons of sediment per year; this is 0.3 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments on some utility lines pose very low risk of accidental direct application of herbicides to streams.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 7,050 acres, underburns on 38,709 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 7,700 tons from prescribed fire and 4,700 tons from wildfire, for a total of 12,400 tons.

Visual

Visual impacts result mainly from prescribed fire, herbicide, and mechanical treatments. Visitors viewing the treated areas see significant vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Vegetation management may affect the availability of recreation opportunities through temporary site closures to remove hazard trees, prescribe burn and spray toxic plants. Prescribed burning may temporarily affect air quality and restrict visibility around some recreation areas. Broadleaf plants and those which produce edible berries and fruit may be included as herbicide target species or be inadvertently sprayed and thereby lost for recreation opportunities; this risk is extremely low due to strong emphasis on selective herbicide treatments.

Cultural Resources

Reduced intensity and reduced acreage of mechanical treatments from Plan levels allows a moderate potential for cultural resource damage. Risk from fire is unchanged.

Socioeconomic Conditions

MODIFIED D provides primitive or semi-primitive forest settings as well as rural settings. Some social conflict occurs due to decreased use of manual and mechanical methods, and the possibility of aerial herbicide application. This conflict is moderated by the use of only low or moderate intensity prescribed burning, and limited aerial herbicide application. Employment opportunities are comparable to current. Managed output levels are unchanged, but per unit costs are slightly lower. Total cost of vegetation management is $6.93 million, per acre costs are $54.52.

Alternative E

Use of prescribed fire and herbicides is reduced. Minimum risk herbicides are applied by hand and machine. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 122,367.

Human Health and Safety

Total acres treated by manual and fire methods combined are nearly the same as at present. Accidents are expected to remain unchanged from the current program since the increase from manual treatments will be offset by the reduction in accidents from prescribed fire. Lengthening the frequency of fuel reduction burns to an average of once every 9 years may slightly increase indirect risks from wildfire.

Reduction of the herbicide program by 1/2 from the current has only minimal effect on public health or safety. Worker safety is improved slightly by a reduction of about one accident every 2 years; health risk from herbicides is unchanged.

The increase in mechanical method use will slightly increase the number, but not the severity, of accidents expected in this phase of the vegetation management program.

Overall risk to workers and the public should be essentially the same as at present, although there may be a slight shift in the actual cause of the accidents.

Vegetation

Herbicide use is decreased; treatment occurs on a projected 12,593 acres annually. Effects are similar to B, but the addition of machine broadcast treatment increases the risk of damage to non-target plants.

Prescribed burning for fuel reduction projected to occur on a 9-year cycle increases risk of plant injury and mortality from wildfire. At highest risk are those young pine, pine-hardwood, and hardwood stands in the smaller size classes. Low to moderate intensity dormant season underburns at this cycle produce a greater number of woody species growing into the understory and midstory. Herbaceous species decrease in number. Growing season burns for site preparation or bald maintenance produce a greater number and variety of herbaceous species.

Mechanical tools causing only low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline in woody species. Since

no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

On manually treated areas, repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems. The number of areas needing additional treatment significantly increases over present levels.

Prescribed burning projected to occur on a 3-year cycle, as well as grazing, mowing, and manual treatments adequately maintains herbaceous species on grassy balds. Increased woody species control occurs with combination treatments such as early growing season burns followed by grazing or mowing. Herbicide treatments for balds maintenance are not allowed. In areas with significant woody species encroachment repeated treatments or more combination treatments are needed to effectively control sprouting hardwoods.

Wildlife

Habitat for some species such as turkey declines due to the long burning cycle. High use of mechanical treatments leaves fewer snags for raptors than manual or herbicide methods but results in more downed logs for reptiles and amphibians.

Threatened, Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 9 years for fuel reduction. Slash burns occur on a projected 616 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is projected to occur on about 270 acres per year and raking is not used.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,040 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 9,096 acres per year). Low to moderate treatment intensity produces about 390 tons of sediment per year; this is 0.2 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 616 acres, underburns on 29,292 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 4,700 tons each from prescribed fire and wildfire, for a total of 9,400 tons.

Visual Quality

Visual impacts result mainly from prescribed fire and mechanical treatments. Visitors viewing the treated areas see vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Vegetation management may affect the availability of recreation opportunities through temporary site closures to remove hazard trees, prescribe burn, and spray toxic plants. Prescribed burning may temporarily affect air quality and restrict visibility around some recreation areas. Broadleaf plants and those which produce edible berries and fruit may be included as herbicide target species or be inadvertently sprayed and thereby lost for recreation opportunities.

Cultural Resources

The reduction in prescribed fire use does not increase risk to cultural resources, and increased use of mechanical methods creates relatively high risk to cultural resources.

Socioeconomic Conditions

Alternative E slightly favors primitive or semi-primitive forest settings but allows rural settings also. Some social conflict exists due to increased use of manual and mechanical methods, and decreased use of prescribed fire and herbicides. This conflict is moderated by low to moderate disturbance mechanical tools. Employment opportunities are high (moderated by about a 6% decline in annual treatments). Outputs are only slightly below Plan levels. Per acre costs are $61.02, total costs are $7.29 million.

Alternative MODIFIED E

Use of prescribed fire and herbicides is reduced, and acres of pine site preparation and timber stand improvement are halved. Minimum risk herbicides are applied by hand and machine. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 108,328.

Human Health and Safety

Total acres treated by manual and fire methods combined are nearly the same as at present. Accidents are expected to remain unchanged from the current program since the increas from manual treatments will be offset by the reduction in accidents from prescribed fire. Lengthening the frequency of fuel reduction burns to an average of once every 9 year may slightly increase indirect risks from wildfire.

Reduction of the herbicide program by 2/3 from the current has a slight effect on public health or safety. Worker safety is improved slightly by a reduction of about one accident every 3 years; health risk from herbicides is unchanged.

Mechanical method use is virtually unchanged from the present.

Overall risk to workers and the public should be essentially the same as at present, although there may be a slight shift in the actual cause of the accidents.

Vegetation

Herbicide use is decreased; treatment occurs on a projected 7,529 acres annually. Effects are similar to B, but the addition of machine broadcast treatment slightly increases the risk of damage to non-target plants.

Prescribed burning for fuel reduction projected to occur on a 9-year cycle increases risk of plant injury and mortality from wildfire. At highest risk are those young pine, pine-hardwood, and hardwood stands in the smaller size classes. Low to moderate intensity dormant season underburns at this cycle produce a greater number of woody species growing into the understory and midstory. Herbaceous species decrease in number. Growing season burns for site preparation or bald maintenance produce a greater number and variety of herbaceous species.

Mechanical tools causing only low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline in woody species. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

On manually treated areas, repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on most cut hardwood stems. The number of areas needing additional treatment significantly increases over present levels.

Prescribed burning projected to occur on a 3-year cycle, as well as grazing, mowing, and manual treatments adequately maintains herbaceous species on grassy balds. Increased woody species control occurs with combination treatments such as early growing season burns followed by grazing or mowing. Herbicide treatments for balds maintenance are not allowed. In areas with significant woody species encroachment repeated treatments or more combination treatments are needed to effectively control sprouting hardwoods.

Wildlife

Habitat for some species such as turkey declines due to the long burning cycle. High use of mechanical treatments leaves fewer snags for raptors than manual or herbicide methods but results in more downed logs for reptiles and amphibians.

Threatened, Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 9 years for fuel reduction. Slash burns occur on a projected 3,589 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is projected to occur on about 45 acres per year and raking is not used.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 1,400 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 6,674 acres per year). Low to moderate treatment intensity produces about 240 tons of sediment per year; this is 0.1 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 3,589 acres, underburns on 29,250 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 5,200 tons from prescribed fire and 4,700 tons from wildfire, for a total of 9,900 tons.

Visual Quality

Visual impacts result mainly from prescribed fire and mechanical treatments. Visitors viewing the treated areas see vegetation disruption up to 6 months after treatments. Treatments normally meet retention to modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Vegetation management may affect the availability of recreation opportunities through temporary site closures to remove hazard trees or prescribe burn. Prescribed burning may temporarily affect air quality and restrict visibility around some recreation areas. Broadleaf plants and those which produce edible berries and fruit may be included as herbicide target species or be inadvertently sprayed and thereby lost for recreation opportunities; this risk is minimal due to the small herbicide program and the strong emphasis on selective treatments.

Cultural Resources

The reduction in prescribed fire use does not increase risk to cultural resources, and slightly increased use of mechanical methods creates somewhat higher risk to cultural resources.

Socioeconomic Conditions

Alternative Modified E slightly favors primitive or semi-primitive forest settings but allows rural settings also. Some social conflict exists due to increased use of manual methods and decreased use of prescribed fire and herbicides. Employment opportunities are high (moderated by about a 17% decline in annual treatments). Outputs are only slightly below Plan levels. Per acre costs are $68.34, total costs are $7.21 million.

Alternative F

Herbicides are not used. Mechanical tools cause low to moderate disturbance. Prescribed fire is of low to moderate intensity. Projected acres treated per year total 130,045.

Human Health and Safety

Elimination of herbicides from the vegetation management program results in an overall increase in the number of accidents experienced by workers. Use of manual methods on 1.5 times as many acres as at present causes the greatest increase in accidents; fire use increases about 6 percent and so do fire related accidents; and mechanical use increases about 20 percent resulting in a slight added risk of worker accidents.

Elimination of herbicides slightly improves related public health and safety when compared to the present. However, increased use of the other methods to achieve the same acreage treated as at present causes a major net increase in risk to worker safety with negligible human health risk reduction.

Vegetation

Prescribed burning for fuel reduction projected to occur on a 6-year cycle adequately controls the buildup of hazardous fuels. Low to moderate intensity dormant season underburns at this cycle produce a mix of woody and herbaceous mid- and understory species. Growing season burns for site preparation or bald maintenance can be expected to produce a greater number and variety of herbaceous species.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatment.

Where manual methods are used, repeated treatments must occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on cut stems. The highest number of repeated treatments will occur in this alternative.

Prescribed burning projected to occur on a 3-year cycle, as well as grazing, mowing, and manual treatments adequately maintains herbaceous species on grassy balds. Increased woody species control occurs with combination treatments such as early growing season burns followed by grazing or mowing. Herbicide treatments are not allowed. In areas with significant woody species encroachment repeated treatments or more combination treatments are needed to effectively control sprouting hardwoods.

Wildlife

All methods except biological and herbicides are available to manage for a broad range of wildlife species. High use of mechanical tools creates habitat for species like doves which use very early successional stage habitat. The 4-year prescribed burning cycle improves habitat for fire-dependent species and is generally favorable for species needing soft mast, such as deer and turkey. Absence of broadcast herbicide treatments favors hard and soft mast producers used by many species. Mechanical site preparation leaves fewer snags than alternative C but creates more downed logs used by reptiles and amphibians, unless combined with slash burning.

Threatened, Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 3 years on balds and in habitat for threatened and endangered species; 4 years in other wildlife habitat; and 6 years for fuel reduction. Slash burns occur on a projected 8,400 acres per year and are estimated to be 50 percent light and 50 percent moderate. Piling is projected to occur on about 310 acres per year and raking is not used.

Moderate slash burns, 3-4 year underburns, and piling pose low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 2,820 acres. No soils are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by fire and mechanical site preparation (projected 12,314 acres per year). Herbicides are not used, so their effects are nil. Treatment intensity is low to moderate, producing about 750 tons of sediment per year; this is 0.4 percent of natural sediment yield from the national forests. Effects on stormflows are minimal.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 8,400 acres, underburns on 38,263 acres, grass burns on 994 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 8,200 tons from prescribed fire and 4,700 tons from wildfire, for a total of 12,900 tons.

Visual

Visual impacts result from prescribed fire, manual, and mechanical treatments. Visitors viewing treated areas see vegetation disruption and ground disturbance up to 6 months after treatments. Treatments normally meet retention to maximum modification visual quality objectives.

Recreation

Sufficient treatment methods exist to manage most recreation sites' vegetation. The effects are similar to alternatives C, D, and E except the absence of herbicide use gives more opportunities for berry and fruit picking, but more potential hazard to workers exist in removing toxic plants by manual methods to reach adequate levels of plant control.

Cultural Resources

Risks to cultural resources are comparable to current with a very slight increase in risk from prescribed fire.

Socioeconomic Conditions

Alternative F balances primitive or semi-primitive and rural settings. Some social conflict exists due to increased use of fire, manual and mechanical methods and the lack of herbicide use. Employment opportunities are very high due to the large number of manual treatments. Outputs are at Plan levels. Per acre costs are $52.84, and total costs are $6.72 million.

Alternative G

Prescribed fire is not used. Minimum risk herbicides are applied by hand, machine, and helicopter. Mechanical tools cause low to moderate disturbance. Projected acres treated per year total 106,912.

Human Health and Safety

Disallowing the use of fire for vegetation management significantly increases public and worker risk from wildfire. Increased herbicide use results in a slight increase in worker risk by one additional accident every 3 years. Since aerial herbicide application is permitted on 2,100 acres per year, a very slight increase in public risk from offsite drift is experienced . However, use of aerial application primarily on power and gas line rights-of-way and in site preparation areas should minimize this risk; sites treated are well marked and are often remote. Due to use of less risky herbicides at reduced rates per acre, overall risk to human health is about the same as in the current program. Use of manual method increases with a proportional increase in the number (but not the severity) of related accidents. Increased mechanical treatments will cause a negligible increase in worker risk.

The overall effect is a significant decrease in risk to workers, and a very slight overall increase in public risk. Increased wildfire risk is the chief factor in increasing public risk.

Vegetation

Herbicide use is projected to increase to 37,440 acres per year, which increases the risk of damage to non-target vegetation.

The elimination of the use of prescribed fire for fuel reduction causes significant risk of injury and mortality to vegetation from wildfire, especially in arson-prone areas. At highest risk from wildfire are those young pine and pine-hardwood stands in the smaller size classes. In the Mountains, longleaf pine stands are at increased risk to brownspot disease, while loblolly pine stands are at increased risk to annosus root rot and fusiform rust. Woody species increase, while herbaceous species decline. Shade-tolerant woody species gradually replace shade-intolerant species in the midstory and overstory.

Mechanical tools causing low to moderate soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations (such as shearing and piling) produce a greater decline. Since no raking or heavy disking occurs, mortality of woody species through uprooting is very low. Woody species fully recover within 5 to 10 years following treatments.

Increased use of manual methods in more areas causes a substantial increase in the amount of repeated treatments on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedlings or saplings due to the rapid growth of single and multiple sprouts on cut stems.

The use of prescribed fire is not allowed. Grazing, mowing, manual, and selective herbicide treatments marginally maintain herbaceous species on grassy balds. Increased woody species control occurs with combination treatments such as manual cutting followed by selective herbicide treatment. Increased selective herbicide treatments as well as repeated manual and mechanical treatments and more combination treatments are needed to effectively maintain herbaceous species on grassy balds.

Wildlife

Habitat for species such as turkey and quail declines due to lack of prescribed fire. Some habitat for species requiring later successional stages is lost as increased wildfires create more habitat for early successional species. Mast production declines due to the increase in broadcast herbicide applications.

Threatened, Endangered, Proposed, and Sensitive Species

Lack of prescribed fire prevents recovery of some fire-dependent species. Other treatments available to manage habitat allow for maintenance or recovery of other species.

Soil

Fire protection plus lack of underburns allows wildfire hazard to increase in some fuel types through progressive fuel buildup. Wildfires are estimated to burn about 30 percent more acres than at present. Some of these acres are severely burned, resulting in impaired soil productivity.

Prescribed fire does not occur, so its effects on soil are nil. Piling is projected to occur on about 220 acres per year and raking is not used. Piling poses low risk to productivity of poor soils only. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 240 acres. No soils are seriously affected by vegetation management.

Water and Aquatic Life

Nearly all sediment is caused by herbicide and mechanical site preparation (projected 13,432 acres per year). Low to moderate treatment intensity produces about 460 tons of sediment per year; this is 0.3 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatment of some utility lines and site preparation projects poses some risk of accidental direct application of herbicides to streams.

Wildfire and Air Quality

Prescribed fire is not used, so wildfires are estimated to increase to at least 10,400 acres per year and are more intense in some fuel types. Annual smoke emissions from national forests are estimated at 6,100 tons per year, all from wildfires.

Visual Quality

Visual impacts result mostly from manual, mechanical, and herbicide treatments. Effects from most manual and mechanical methods should be insignificant after 3 to 4 months. Wildfires are more intense, which increases mortality and creates a negative visual effect. Broadcast herbicide applications create seasonal browning that attracts viewer attention up to 6 months. Treatments meet visual quality objectives from retention to maximum modification.

Recreation

Sufficient treatment methods exist to manage vegetation to provide safety for recreation visitors and to protect the investment in facilities. Effects are similar to those in alternatives C, D, and E except that the lack of prescribed burning allows some dispersed areas to be invaded by dense vegetation reducing the utility for recreation activities.

Cultural Resources

Lack of availability of prescribed fire could magnify risks from wildfire, however unlike alternative A other tools are available so that fire breaks or other protection are afforded. Risks are slightly lower than current.

Socioeconomic Conditions

Alternative G modifies the setting appearance by eliminating the use of prescribed fire. This causes some social conflict. Additional conflict is due to use of aerial application of herbicides and an increase in the number of herbicide-treated acres. While employment opportunities increase with increased use of manual, there is a concurrent decrease due to elimination of prescribed fire (perhaps even a decline in overall employment). Output levels are generally unchanged. Total costs are $5.62 million, per acre costs are $54.00.

Alternative H

Vegetation management is done to achieve maximum vegetation control. Herbicides are broadcast at maximum effective rates by hand, machine, and helicopter. Intense mechanical tools and prescribed fire are used more frequently than at present. Projected acres treated per year total 171,671.

Human Health and Safety

Herbicide application is permitted by all ground methods (manual or mechanical) and can be either broadcast or selective. Overall, ground application methods pose no significant risks of acute, sub-chronic, or chronic toxicity, nor do they pose significant cancer or mutagenicity risks to workers or the public. Exceptions (2,4-D, 2,4-DP, and tebuthiuron) are noted in the discussion of human health effects. Mitigation which would ensure that risk to workers and the public meet EPA's ecological risk standards for all evaluated herbicides and additives, is not considered beyond that currently in effect .

Doubling the number of acres treated with herbicides results in an additional worker accident every 2 years. Public risk of exposure increases slightly with the use of aerial application on 8,700 acres per year, but worker risk declines in this method. Treating 133 percent of current acreage by prescribed fire causes an increased risk to workers. Primarily due to the large size of the program proposed, workers and the public are at greater risk than at present from this alternative.

Vegetation

Projected increase in acres treated using herbicides, and increased frequency and intensity of treatments, permit almost complete control of competing woody or herbaceous vegetation and puts non-target vegetation at highest risk. Broadcast herbicide application by helicopter, mechanical equipment, or hand ground tools occurs on a projected 50,984 acres per year. Aerial application occurs on utility rights-of-way, site preparation, release areas, and balds.

Prescribed burning for fuel reduction projected to occur on a 4-year cycle more than adequately controls the buildup of hazardous fuels. Dormant season underburns at this cycle produce a mix of woody and herbaceous mid- and understory species. Reductions in some woody species reproduction and development occurs, and greater numbers of herbaceous species predominate. Use of higher intensity fire for both dormant and growing season burns also reduces woody species and increases herbaceous species.

Mechanical tools causing low to high soil disturbance are used. Herbaceous species initially increase, then decline within 3 to 5 years, depending upon tool intensity. Woody species initially decline. Higher intensity tools or combinations produce a greater decline. Some mortality of woody species occurs through uprooting by raking and disking. Most woody species fully recover within 5 to 10 years following treatment.

Manual methods slightly increase. Where used, some repeated treatments will occur on sites with high numbers of competing stems in order to successfully release or precommercially thin pine and hardwood seedling or saplings due to the rapid growth of single and multiple sprouts on cut stems.

Prescribed burning projected to occur on a 2-year cycle, as well as grazing, mowing, manual, and selective herbicide treatments more than adequately maintains herbaceous species on grassy balds. Early growing season burns at this cycle would provide the greatest amount of woody species control. Additional woody species control occurs with combination treatments such as early growing season burns followed by grazing or mowing.

Wildlife

Maximum vegetation control limits production of hard and soft mast used by deer, turkey and other species. Higher burning intensity and frequency combined with herbicide treatments severely reduce hardwood midstories used by songbirds like tufted titmouse (*Parus bicolor*), but may increase soft mast production. Snags for raptors and downed logs for reptiles and amphibians are less available than in other alternatives.

Threatened Endangered, Proposed, and Sensitive Species

Only prescribed fire and manual methods are available for T&E species habitat management. Mitigation measures assure adequate inventory of proposed, sensitive, threatened, and endangered species and protect populations from adverse effects of vegetation management. Recovery is likely if impacts from external factors are controlled.

Soil

Underburns occur every 2 years on balds, 3 years in wildlife habitat, and 4 years for fuel reduction. Slash burns occur on a projected 5,050 acres per year and are estimated to be 20 percent light, 50 percent moderate, and 30 percent severe. Piling and raking are each projected to occur on about 110 acres per year.

In general, 2-year underburns pose medium risk to soil productivity. Other underburns, moderate slash burns, and piling pose low risk to productivity of poor soils only. Severe slash burns and raking pose high risk on good soils and extreme risk on fair and poor soils. Effects of all other tools are minimal. Over time, risk to soil productivity from vegetation management is estimated to be low on 3,550 acres, medium on 4,090 acres, high on 93,410 acres, and extreme on 4,140 acres; 2.0 percent of the national forests are seriously affected.

Water and Aquatic Life

Nearly all sediment is caused by non-manual site preparation (projected 20,563 aces per year). Broadcast herbicides, intensive mechanical tools, and severe slash burns are favored. Treatments produce about 2,150 tons of sediment per year; this is 1.2 percent of natural sediment yield from the national forests. Effects on stormflows and herbicide concentrations are generally minimal. Aerial treatments, however, pose the greatest risk of accidental direct application of herbicides to streams.

Wildfire and Air Quality

Each year, slash burns are projected to occur on 5,050 acres, underburns on 54,007 acres, grass burns on 1,052 acres, and wildfires on 8,000 acres. Annual smoke emissions from national forests are estimated at 8,000 tons from prescribed fire and 4,700 tons from wildfire, for a total of 12,700 tons.

Visual Quality

This alternative creates significant visual impacts with more treatment acres meeting the maximum modification visual quality objective. Prescribed fire, mechanical, and herbicide treatments are used more and at higher intensity. These increases result in significant color and textural changes readily noticed by visitors, lasting up to 1 year. Individual treatment effects may not meet the assigned visual quality objective.

Recreation

Vegetation treatments in and near recreation sites would be applied increased levels from alternatives C, D, and E with similar effects. All tools are available to choose the least detrimental method for each site's condition and need. Dispersed recreation areas can be kept more open for a diversity of activities.

Cultural Resources Extensive use of fire and the full range of mechanical treatments pose a high risk of negative effects. Treatment of more acres than any other alternative also increases risk.

Socioeconomic Conditions Alternative H directly benefits those who enjoy a rural forest setting, and negatively affects those who enjoy more primitive settings. Social conflict is caused by the magnitude of the change from current actions, and the perception that one group was receiving most of the benefits while another was suffering most of the losses. Employment opportunities are higher than current due to more treated acres. Outputs exceed Plan levels. Total costs are $9.10 million, per acre costs are $53.92.

O. RESEARCH NEEDS

No critical information is missing that would prevent implementation of any alternative in this EIS. However, the analysis did reveal a need for more research in several areas.

Research is an integral part of work done on national forests and is used to acquire knowledge of environmental processes and relationships. Information concerning effects of vegetation management, derived from existing research studies, forms the basis for most of the conclusions of this document.

Following are the major research needs identified. Only items 1 through 5 relate to incomplete or unavailable information identified as data gaps in sections B, D, F, and G of this chapter (40 CFR 1502.22). Items 6 through 17 are other important research needs.

1. Public, worker, and wildlife exposure from use of different herbicides and application rates.

2. Synergistic and cumulative effects of herbicides.

3. Herbicide effects on wildlife, including effects on habitat, chronic toxicity, and oncogenic and mutagenic potential.

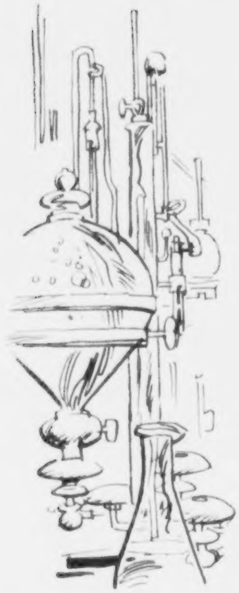
4. Long-term effects on soil and water from varying severity of slash burns and from varying frequency and season of underburns.

5. Effects of vegetation management methods on streamflows and channel erosion, and rates of channel erosion in undisturbed forests.

6. Movement of all 11 herbicides to streams and ground water, using typical application rates, over the full range of application methods and soil, geologic, and topographic conditions in the South.

7. Relationship of prescribed fire effects on wildlife (especially reptiles, amphibians, and songbirds) to fire behavior, including intensity, duration, and season.

8. Effectiveness of prescribed fire in promoting advanced oak regeneration in cove sites and producing quality hardwood sprouts.



9. Effects of long-term periodic underburns in upland pine, pine-hardwood, hardwood-pine, and hardwood stands on stand quality and understory species composition.

10. Relationships between air pollution, CO_2 production, ozone layer depletion, and plant growth and reproduction.

11. Composition, interrelationships, and potential indicator species of understory plant communities.

12. Effectiveness of biological vegetation controls, including light inhibitors, livestock, insects, and allelopathic plants.

13. Long-range (multi-rotational) effects on wildlife and plants (especially sensitive, threatened, and endangered species) from vegetation management, including growing and dormant season burns.

14. Long-term effects of intensive mechanical site preparation treatments on soil, water, reptiles, and amphibians.

15. Effects of increased sediment yields on aquatic species and their habitat.

16. Effects of prescribed fire on wildfire occurrence and air quality both locally and regionally.

17. Effects of all methods and their combinations used to maintain mountaintop balds.

P. ENERGY REQUIREMENTS

The principal energy source for vegetation management is fossil fuel. Every alternative except A consumes fuel (usually petroleum) either directly, such as in vehicles, machinery and equipment, or indirectly, such as an ingredient in herbicides or in a manufacturing process. Another energy source which is sometimes consumed is loggin debris which has potential household or industrial uses.

Energy requirements for vegetation management are only a small part of the total energy required for all management activities occurring on national forests. While there are variations between alternatives (A uses none, B requires the least, and H requires the most), these variations are not significant.

Q. POSSIBLE CONFLICTS WITH OTHERS

Other local, State and Federal agencies have vegetation management programs of their own and may be affected by actions done under the preferred alternative. Some of these agencies have overlapping responsibilities with the Forest Service, and some have administrative authorities to prescribe limits on certain types of adverse effects.

None of these agencies asked to be a "cooperating agency" under the provisions of the National Environmental Policy Act. However, many have participated in the preparation of this environmental impact statement:

- The Environmental Protection Agency has provided information on environmental standards and testing procedures.
- The Fish and Wildlife Service has assisted with data and requirements for compliance with the Endangered Species Act.
- The Tennessee Valley Authority has assisted with rights-of-way analysis and provided cost statistics.
- State Foresters have been represented by a part-time team member and have reviewed some analytical results.
- Chapter VI contains a list of agencies at all levels which reviewed the Draft EIS.

Few apparent conflicts with others have been noted. One is that management intensities on national forests can be expected to differ from intensities on other lands. Privately-owned lands are managed for many different purposes, and even Federally-managed lands nearby can be expected to be different. National Parks, for example, are managed for altogether different objectives than National Forests. The uninformed visitor could have unrealistic expectations that all lands should have similar management, particularly when they are adjacent. Management intensities will differ depending on the mission and objectives of the responsible agency or private landowner.

Alternatives A and B reduce payments to local governments relatively quickly, and alternative G is likely to reduce them over the long term. Selection of such alternatives requires more intense coordination with these governments because they envision substantial program revisions.

Conflicts will occur with Forest Land and Resource Management Plans. Plans assumed that all vegetation management methods are available. The Regional Forester's decision about which mix of methods to use, based on this analysis, could be different from assumptions in Plans. Forest Supervisors will evaluate the Regional Forester's decision and its effect on Plans and make changes as needed. The Forest Service will use and incorporate by reference any relevant information from this EIS and those accompanying Plans when conducting site-specific analyses for vegetation management projects.

R. ADVERSE ENVIRONMENTAL EFFECTS THAT CANNOT BE AVOIDED

Despite mitigation measures, some significant adverse effects are unavoidable, some in alternative A only, and some in any alternative where vegetation management is done. These effects are:

1. Health and Safety	Worker accidents occur through use of vegetation managemen methods, especially manual methods and prescribed fire.
2. Vegetation	Individual non-target plants are injured or killed by vegetation management. Some methods and tools have greate effects than others; intensive broadcast treatments have t greatest effect.
3. Wildlife	Wildlife requiring mature forests is displaced or lost fro some habitats by vegetation management which prolongs earl stages of plant succession. Wildlife requiring open areas is displaced as young stands age, especially in alternativ A.
4. Threatened, Endangered, Proposed, and Sensitive Species	Lack of vegetation management in alternative A reduces populations or prevents recovery of some animals and plan that can exist only in forests experiencing periodic disturbances.
5. Soil	Soil productivity is impaired where intensive prescribed fire or mechanical methods cause excessive loss of soil organisms, organic matter, and nutrients in alternatives and H.
6. Water and Aquatic Life	Water quality is impaired in some small streams that drai areas where high disturbance tools are used in alternati C and H, or that are accidentally overflown during aeria herbicide application in alternatives D, Modified D, G, H.
7. Air Quality	Smoke from prescribed fires or wildfires temporarily imp air quality in every alternative.
8. Rights-of-Way	Lack of treatment in alternative A allows vegetation to encroach on rights-of-way, threatening public safety on roads and trails and impairing operation of utility lin

9. Visual Quality

Visual quality is temporarily impaired by vegetation management methods. Lack of treatment in alternative A may also cause impairment.

10. Wildfire

Lack of prescribed fire in alternatives A and G allows fuels to build to dangerous levels in some fuel types and increases probability and severity of wildfire damage.

11. Socioeconomic Conditions

Any action or lack of action is acceptable to some people and unacceptable to others. This disagreement creates social conflict about vegetation management. Conflict is created whenever there are changes from current ways of doing things.

S. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

An irreversible commitment is one in which nonrenewable resources are permanently lost. Such losses occur when oil, gas, coal, or petroleum products are consumed and cannot be replaced. Some endangered plants occurring only on national forests may be irreversibly lost in alternative A. Soil productivity may be impaired for many decades on sites where raking or severe slash burns are used in alternatives C and H.

An irretrievable commitment is one in which resource production or use is lost while managing an area for another purpose. If we choose not to manage a resource, we do so knowing we lose its potential value had it been managed. All alternatives eliminate or reduce management of some resources, while emphasizing others.

This EIS makes no irreversible or irretrievable commitment of resources. It displays the projected effects of vegetation management for the activities listed in chapter I. Any irreversible or irretrievable commitment of resources will occur at the project level and be disclosed by a site-specific analysis.

T. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

National forests must be managed to protect long-term productivity of the land. Long-term productivity is the capability of forests to provide resources into the future. Most management activities and resource outputs are short-term uses. When decisions are made to produce these outputs, long-term productivity could be affected. Generally, mitigation measures reduce or eliminate effects on long-term productivity by protecting soil, water, wildlife, and threatened and endangered plants and animals. Where raking or severe slash burns are used, however, loss of long-term soil productivity is inevitable.

Monitoring requirements which apply to all alternatives are designed to provide feedback to managers who ensure that long-term productivity is not impaired by short-term uses. If monitoring discloses that management requirements and mitigation measures are inadequate, new ones will be developed.

List of Preparers

CHAPTER V

LIST OF PREPARERS

A. INTERDISCIPLINARY TEAM SELECTION

The Regional Forester and his staff evaluated the need to prepare an environmental impact statement and identified activities which needed to be analyzed. Once analysis needs were known, a team leader was selected and he and the Regional Forester looked at the Region's work force to locate individuals with education and experience necessary to complete the analysis.

Team members listed below represent a broad mix of experience and specialized training. Specialties cover a wide range of resources and all members are highly experienced in natural resource and human resource management. The team prepared this EIS. Some of the work they did was identifying and examining issues, developing and evaluating alternatives, researching and analyzing environmental effects, and studying and responding to public comments.

B. FULL-TIME TEAM MEMBERS

Steve McCorquodale is the team leader. He has a Bachelor of Science degree in Forestry from McNeese State University at Lake Charles, Louisiana. Steve is completing his 24th year with the Forest Service and has had assignments in North Carolina, Texas, Virginia, Mississippi, Kentucky, Alabama, and Georgia. His principal area of expertise is in fire management; in addition, his positions have given him responsible administrative and supervisory experience in recreation, silviculture, public affairs, minerals, and wilderness. Steve is an avid hunter and fisherman and pursues his interests in natural resources through active memberships in Society of American Foresters and American Forestry Association.

Interdisciplinary team responsibilities include overall management and supervision as well as coordination with others and accountability to management.

Ann Cason is the program assistant. She has specialized secretarial education through several Office of Personnel secretarial, business management, and administration courses. Ann is completing her 26th year of Federal service and has had assignments with the Environmental Protection Agency, Department of Justice, U. S. Geological Survey, Department of Defense, and for the last 8 years with the Forest Service. Assignments in positions such as dministrative technician, clerk-stenographer, secretary, and executive secretary have given her broad administrative experience. Ann enjoys gardening and walking.

Her responsibilities on the team include internal and external scheduling, correspondence, computer management, financial management, and travel.

Jim Maxwell is the team hydrologist. He has a Bachelor of Science degree in Forest Hydrology from Utah State University at Logan, Utah. Jim is completing his 18th year with the Forest Service and has had assignments in California, Utah, Idaho, West Virginia, Oregon, New Mexico, and Georgia. His principal area of expertise is in streamflow-sediment dynamics. In addition his positions have given him supervision and administration experience in stream and fisheries protection, rainfall-runoff relationships, and influence of climate. Jim is an avid hiker and river floater.

Responsibilities as a team member are for analysis of soil, water, and air resources; and evaluation of cumulative effects.

Paul A. Mistretta is the team plant pathologist. He has a Bachelor of Science degree in Biology from Fordham College, New York, New York; a Master of Forestry degree (forest protection) from Duke University, Durham, North Carolina; and a Doctor of Philosophy in plant science from the University of Maine at Orono. Paul is completing his 12th year with the Forest Service and has had assignments in Georgia and Louisiana. His principal area of expertise is in epidemiology of forest tree diseases. He also has 2 years experience as a graduate teaching assistant. He has authored or coauthored over 40 publications and is active i several professional societies. Paul enjoys philately and computer programming.

Responsibilities as a team member are for coordination of risk assessment, toxicology, and rights-of-way analyses an incorporation of those analyses into the EIS.

Jane Sell is the editorial assistant. She has enhanced he skills through on-the-job training. Jane is completing he 16th year with the Forest Service and has had assignments clerk-typist and clerk-stenographer. Her experience as owner-operator of a printing company for 12 years and additional administrative-editorial experience with other environmental documents with the Forest Service give her broad qualifications. Jane actively pursues outdoor spor

Team support responsibilities are to manage filing and d systems, assist with edit and layout, and to coordinate literature search.

Gary Sick is the team public affairs specialist. He has a Bachelor of Science degree in Geological Sciences from the State University of New York at Geneseo, New York and a Master of Science degree in Forestry (policy analysis) from Michigan State University at East Lansing, Michigan. Gary is completing his 11th year with the Forest Service and has had assignments in Mississippi, Arkansas, Michigan, and Georgia. His principal area of expertise is in minerals management. In addition, his positions have given him responsible management experience in data management, environmental planning, and water quality analysis. Earlier experience includes 3 years in social work and one year in public schools. Gary enjoys most outdoor recreation, especially fishing.

Responsibilities on the team are NEPA compliance, scoping, media and document production.

Cynthia A. Witkowski is the team silviculturist. She has a Bachelor of Science degree in Natural Resource Conservation from the University of Connecticut at Storrs, Connecticut. Cindy is completing her 12th year with the Forest Service and has had assignments in South Carolina, Arkansas, Louisiana, and Georgia. Her principal area of expertise is in timber and silviculture. Her positions have also given her responsible management experience in administration, recreation, minerals, wildlife, and human resources. Two years with the Peace Corps also gave her broad natural resource management skills. Cindy enjoys golf and fishing and has active memberships in the Society of American Foresters.

Team responsibilities are analysis and coordination of silviculture, wildlife, and range.

C. PART-TIME TEAM MEMBERS

Joel Artman is a team member from the Virginia Department of Forestry. He attended the University of Tennessee; received a Bachelor of Science degree in Forest Management from North Carolina State University and a Master's degree from Duke University in Forest Pathology. Joel has been with the Virginia Department of Forestry for about 25 years and currently occupies the position of chief of the Pest Management Branch. One of his primary duties involves the operational and testing efforts in chemical site preparation and pine release for the Department's pesticide programs. He enjoys crocheting and woodworking during the winter, while summer's spare time is occupied canoeing, camping, and messing with snakes.

Team responsibilities include input and review for herbicide use, aerial application, and liaison with Southern Group of State Foresters.

Margaret Boland is the team sociologist. She has Bachelor of Arts and Master of Arts degrees in Sociology from the University of Michigan. Her experience includes 10 years of teaching sociology and doing sociological research before joining the Forest Service 6 years ago. She is currently the public affairs officer for the National Forests in North Carolina.

Team responsibilities are to provide analysis of potential socioeconomic impacts of vegetation management in the southern Appalachians.

Robert M. Carey is a team member from the Toecane Ranger District, National Forests in North Carolina. He attended the University of Delaware and received a Bachelor of Science degree in Forestry from the Pennsylvania State University. He has been a district ranger on the Toecane and Uwharrie ranger districts for 17 years, and has worked in fire, recreation, timber, and wildlife in Virginia, North Carolina, and Oregon. He has been involved in management of Appalachian Mountain balds on Roan Mountain for 7 years.

Team responsibilities include evaluation of Appalachian balds.

Jim Fenwood is the team wildlife biologist. He has a Bachelor of Science degree in Wildlife Management from the University of Maine at Orono, Maine, and a Master of Science degree in Wildlife Management from West Virginia University at Morgantown, West Virginia. Jim has 11 years with the Forest Service and has had assignments in Arkansas and South Carolina. His principal area of expertise is forest wildlife management. In addition, his positions have given him management experience in fire, range, watershed, and recreation. Jim is a certified wildlife biologist and active member of the Wildlife Society, National Audubon Society, and other conservation organizations. He enjoys outdoor writing, photography, and hunting.

Team responsibility is analysis of effects on wildlife habitat and on threatened, endangered, and sensitive specie

Richard Greenhalgh is the Southern Region's economist and provided the Vegetation Management Team economic analysis a part-time basis. He has a Bachelor of Science degree in Vocational Education and a Master of Science degree in Agricultural Economics from University of Nebraska, and a Doctor of Philosophy with emphasis in natural resource economics from the University of Missouri. His experience includes 15 years of research and river basin studies throughout the Southeast with the USDA Economics Research Service, and 9 years as an economist with the Forest Serv

Jim Herrig is the team fisheries biologist. He has a Bachelor of Science degree in Wildlife and Fisheries Science from South Dakota State University and a Master of Science degree in Fisheries Science from Colorado State University. Jim has 8 years of experience with the Forest Service and, in addition to his service in North Carolina, has had assignments in Colorado. His principal area of expertise is cold water fisheries, but he also has experience with threatened and endangered species, and range and wildlife management. Jim is a member of Trout Unlimited and the American Fisheries Society. He enjoys fly fishing, backpacking, and photography.

Team responsibilities are for analysis of vegetation management effects on aquatic species and their habitat.

Charles K. McMahon is supervisory research chemist/project leader; USDA Forest Service, G.W. Andrews Forestry Sciences Laboratory, Auburn University, Alabama. Charles holds a Bachelor of Science from St. Peter's College, a Master of Science degree in chemistry from Rutgers University and a Master's degree in Management from Georgia College. Charles began his Federal career in 1963 as an environmental chemist with the Department of the Army in Salt Lake City and Dugway, Utah. In 1973 he transferred to the U. S. Forest Service, Southeastern Forest Experiment Station, at the Southern Forest Fire Laboratory in Macon, Georgia. In 1987 he transferred to his current position in Auburn with the Southern Forest Experiment Station. Charles's current research is concentrated on the interaction of fire and forest herbicides, worker safety, and the air quality impacts of vegetation management practices. He is a member of the Air Pollution Control Association, American Chemical Society, American Industrial Hygiene Association, and the American Geophysical Union. He is a Fellow of the American Institute of Chemists and a Certified Professional Chemist.

Program responsibilities include analysis of potential air-quality impacts of vegegation management practices.

Jerry Lee Michael holds a Bachelor of Science degree in Chemistry from Elon College, a Master's degree in Plant Taxonomy from the University of North Carolina at Chapel Hill, and a Doctor of Philosophy degree in Tree Physiology from Colorado State University.

He spent 2 years in the U. S. Army as a plant physiologist at Fort Detrick, Maryland. After completion of his Docorate at Colorado State, he went to the University of Georgia as a post-doctoral fellow where he worked on host-physiology related aspects of the southern pine beetle problem and on the physiology of paraquat-induced resin soaking in southern pines.

He is currently employed by the Southern Forest Experiment Station, Forest Service at Auburn University, Auburn, Alabama. His primary work has been research on environmental chemistry of the principal herbicides used in forestry including the immediate and ultimate fate of herbicides applied to forest ecosystems.

Responsibilities as a part-time team member are for analysis and evaluation of herbicide effects.

Dan Neary is the team soil scientist. He has a Bachelor of Science degree in Forestry, a Master of Science degree in Forest Ecology, and a Doctor of Philosophy degree in Forest Soils and Hydrology, all from Michigan State University at East Lansing. Dan is completing his 11th year with the Forest Service. He has had assignments with the New Zealand Forest Research Institute and the Cowetta Hydrologic Laboratory, North Carclina, and is currently part of the Intensive Management Practices Assessment Center, Southeastern Forest Experiment Station at the University of Florida. His principal area of expertise is in the environmental fate and effects of forestry pesticides, but he also has considerable experience with the effects of intensive forestry on soils, site productivity, and water quality. Dan enjoys swimming, sailing, and skiing.

Team responsibilities are for analyses and evaluation of potential herbicide effects, soil and water impacts, and cumulative watershed effects.

Dennis Robertson has a Bachelor of Science degree in Landscape Architecture from the University of Missouri at Columbia, Missouri. He is completing his 22nd year with the Forest Service with assignments in Washington, Wyoming, Arkansas, and Georgia. His principal area of expertise is in resource planning and his assignments have given him management experience in recreation, facilities design, landscape, and rights-of-way design.

Dennis enjoys many outdoor sports and yard work and maintains an active membership in the National Arbor Day Foundation.

Team responsibilities are for analysis of visual quality and rights-of-way maintenance techniques.

Cecil Thomas is a wildlife biologist on the Mount Rogers National Recreation Area of the Jefferson National Forest. He has an A.A.S. Degree from Haywood Technical Institute in Fish and Wildlife Management and continued study at Virginia Highlands Community College. Cecil has 15 years of experience with the U. S. Forest Service in South Carolina and Virginia working in wildlife, range, timber, water, and balds management. Areas of emphasis include management of Appalachian balds, range planning and implementation for vegetation management, cold water fisheries habitat improvement, and threatened and endangered species. His hobbies include hunting, fishing, and equestrian activities.

Team responsibilities include analysis of proposed vegetation management effects on selected threatened, endangered, proposed, and sensitive plant and animal species of the Appalachians.

David Van Lear is a team member from Clemson University. He has Bachelor of Science and Master of Science degrees from Virginia Polytechnic Institute and State University and a Doctor of Philosophy degree from the University of Idaho. Prior to coming to Clemson in 1971, he conducted forest tree nutrition research on a post-doctorate appointment at the University of Florida and worked on strip-mine restoration with the USDA Forest Service in Kentucky. His research over the past 17 years has dealt with silvicultural impacts on water quality and soil properties. He is especially interested in the uses and effects of prescribed fire in the Piedmont and southern Appalachians. He is a Fellow in the Society of American Foresters and is a member of Trout Unlimited and the National Wildlife Federation. David enjoys fly fishing and fly tying.

Team responsibility is to provide technical advice regarding effects and uses of prescribed fire in the southern Appalachians.

Thomas A. Waldrop is research forester with the Southeastern Forest Experiment Station's Pine-Hardwood Silviculture Research Work Unit. He received Bachelor of Science and Master of Forestry degrees in Forest Management from Clemson University and a Doctor of Philosophy in Forest Ecology from the University of Tennessee, Knoxville. Prior to joining the Southeastern Station 2 years ago, Tom was a research associate with Clemson University. His research interests include silvicultural alternatives to establish pine-hardwood mixtures, growth and yield modeling for mixed-species stands, prescribed burning, and fire ecology. He is an active member of the Society of American Foresters, South Carolina Forestry Association, and several other professional organizations. Tom enjoys golf, photography, and Civil War history.

Team responsibility is to provide a history of fire use and an analysis of prescribed fire effects for the Southern Appalachian region.

Joan Walker is the team plant ecologist. She received a Bachelor of Science degree in Biology from Lebanon Valley College, Annville, Pennsylvania and Master of Science and Doctor of Philosophy degrees in Botany from the University of North Carolina, Chapel Hill. She has had post-doctoral research experience at Duke University, and held an Assistant Professor position at Southeastern Louisiana University, Hammond. She has had 8 years of experience working in ecosystems of the Southeast, with an emphasis in coastal plain communities. Primary research concerns have included diversity and production in fire-dependent savannas and flatwoods.

Joan compiled information on threatened, endangered, and sensitive species habitats, and coordinated an effort to assess the effects of management techniques on TES species.

Max Williamson is the USDA Forest Service's regional pesticide specialist. He has a Bachelor of Science degree in Chemistry from Cumberland College at Williamsburg, Kentucky; and a Master of Science degree in Environmental Engineering from Murray State University at Murray, Kentucky. He has completed additional graduate studies in physical sciences and toxicology. He is completing his 26th year with the Forest Service and has broad experience as a pesticide specialist and in resource management. His assignments have been in California, Virginia, North Carolina, Arkansas, Oklahoma, and Georgia.

Responsibility as a team member is to serve in an advisory capacity and to act as liaison with industry and regulatory bodies.

Tom Wiseman is a writer-editor with the team. He has a Bachelor of Arts degree in English from the Pennsylvania State University at University Park, Pennsylvania. He also earned a Master of Arts and a Doctor of Philosophy in English from Tulane University in New Orleans, Louisiana. He served as writer-editor with the Forest Service's Southern Forest Experiment Station for 2 years. Additionally, he edited Forest Farmer magazine for 8 years. He is now assistant professor of English at Southern College of Technology, School of Arts and Sciences in Marietta, Georgia. Tom enjoys fishing, coaching youth basketball, an creative writing.

Team responsibilities include copy editing and writing, assisting with layout and design, and proofreading.

D. ADVISORS, CONSULTANTS AND REVIEWERS

1. Advisors

Larry Bishop, USDA Forest Service, Coop Forestry
Chris Glover, USDA Forest Service, Systems Support
Harold Greenlee, USDA Forest Service, Geometronics
George Hemmingway, USDA Forest Service, Lands and Mineral

Jimmy Huntley, USDA Forest Service, Fisheries and Wildlife
Charles Huppuch, USDA Forest Service, Recreation
Bruce Jewell, USDA Forest Service, Public Affairs
Jean Kruglewicz, USDA Forest Service, NEPA Compliance
Jim Lunsford, USDA Forest Service, Fire
Keith McLaughlin, USDA Forest Service, Soil, Water and Air
Bob Stignani, USDA Forest Service, Recreation
Jimmy Walker, USDA Forest Service, Timber/Silviculture

2. Risk Assessment Review

Joanne E. Betso, Dow Chemical USA
Jim Brewer, JLB International Chemicals
E. Calabrese, University of Massachusetts
Sean Casey, Elanco Products
Dave Clapp, Centers for Disease Control
Bob Cooke, USDI Fish and Wildlife Service
Edwin Dale, Private citizen
Ed Daley, International Paper
Tom Darden, USDA Forest Service
Dean Gjerstad, Auburn University
Jack Gnegy, Westvaco
Larry Gross, USDA Forest Service
Simon K. Hall, American Cyanamid
Zdenka Horakova, USDA Forest Service
George Hurst, Mississippi State University
Kentucky Power Co.
Kentucky Utilities Co.
Timothy J. Long, Montsanto Co.
Bob Lowery, Weyerhaeuser
Bill McComb, Oregon State University
Jerry L. Michael, USDA Forest Service
Hans Muller, US Environmental Protection Agency
Fredrick O. O'Neal, E.I. Dupont Co.
Bill Pope, Potlatch Corporation
John Taylor, USDA Forest Service
R. Thomas, National Academy of Sciences
Shep Zedacker, Virginia Polytechnic Institute

3. Technical Consultants and Review

Richard Ames, USDA Forest Service
Thomas M. Armitage, US Environmental Protection Agency
Ed Buckner, University of Tennessee
Bill Carothers, USDA Forest Service
Andre F. Clewell
John Coleman, USDA Forest Service
Art Cram, Private citizen
Ralph Dimmick, University of Tennessee
George Dissmeyer, USDA Forest Service
Mary Lynn Domilla, USDA Forest Service
Ronald Eislor, USDI Fish and Wildlife Service
Eric Ellwood, North Carolina State University
Ron Escano, USDA Forest Service
Roger Fryar, USDA Forest Service
Glen Glover, Auburn University
Robert K. Godfrey, Florida State University

Paul Hamel, Tennessee Department of Conservation
Dennis Harden, Florida Natural Resources Inventory
Jim Harrison, US Environmental Protection Agency
Gary Hasty, Tennessee Valley Authority
John Hosner, Virginia Polytechnic Institute
Karen Hughes, USDA Forest Service
James Hunt, USDA Forest Service
W. Wayne Johnson, USDI Fish and Wildlife Service
Dave Ketcham, USDA Forest Service
Jim Keys, USDA Forest Service
Ken Knauer, USDA Forest Service
Gary Larsen, USDA Forest Service
Lee Lavdas, USDA Forest Service
Scott Layfield, USDA Forest Service
Carlton R. Layne, US Environmental Protection Agency
Terry Lewis, USDA Forest Service
Troxell O. (Olin) Mason, USDA Forest Service
Gene McGee, USDA Forest Service
Bill McKee, USDA Forest Service
Edwin Michael, West Virginia University
James Miller, Auburn University
Patrick J. Minogue, Auburn University
Logan Norris, Oregon State University
Max Ollieu, USDA Forest Service
James Pack, West Virginia Department Natural Resources
Steve Price, National Park Service
Jerry Ragus, USDA Forest Service
David Saugey, USDA Forest Service
Jesse T. Simmons, Tennessee Valley Authority
Rhey Solomon, USDA Forest Service
Peter Sprints, Texas A&M
Benee Swindel, IMPAC, University of Florida
Richard Tallent, Tennessee Valley Authority
Dale Wade, USDA Forest Service
Tom Wojtalik, Tennessee Valley Authority
Tom Welborn, US Environmental Protection Agency
Carol Wells, USDA Forest Service
Dale Wilhelm, Tennessee Valley Authority

CHAPTER VI

Public Participation and Consultation With Others

CHAPTER VI

PUBLIC PARTICIPATION AND CONSULTATION WITH OTHERS

A. PUBLIC INVOLVEMENT SUMMARY

Because vegetation management issues are often intense and sometimes emotional, a high level of public participation was deemed necessary for satisfactory completion of this environmental impact statement. Therefore, the public has been actively involved in its development. Many people and organizations made valuable contributions to the analysis.

The Forest Service has encouraged public participation throughout EIS preparation. Steps taken to keep the public informed and involved are:

Notice of Intent - A notice of intent to prepare this EIS was published in the September 11, 1986 Federal Register. A revised Notice of Intent, based on early scoping results, was published in the May 5, 1987 Federal Register. This revision described methods which would be evaluated, dates for public review of the draft statement and the completion date for the final statement.

Letter to the Public - The public was asked to identify issues through the use of a post-paid mailer designed for this project. Over 13,000 of these mailers were distributed to interested individuals, groups and agencies in June 1987. To obtain the broadest possible coverage, each forest assembled a list of every party known to them to be interested in national forest management. These lists were then merged into a master list.

Media - Radio, television and the press were included in the request for comments on issues. Additionally a press release was distributed: to regional media by the Regional Public Affairs Office, and to state and local media by individual Forest Public Affairs Offices. The press release was done at the same time as mailers were sent, June 1987.

Meetings - On several occasions between June 1987 and May 1988 members of the interdisciplinary team and designated forest representatives met or spoke with agencies, organizations and individuals whenever the level of interest was appropriate for this type activity. Needs varied from locality to locality with North Carolina and Virginia showing the most intense interest.

Tabloid - In March 1988, 5000 tabloids containing information about the scope, timing and progress of the EIS were distributed. Also included in the tabloid were articles about issues, alternative themes, risk assessment, and some methods proposed for use. A post-paid return envelope was inserted in the tabloid to allow for additional public response. A coupon requesting a copy of the EIS or just inclusion on the mailing list was also printed to offer an opportunity to anyone who might not have already made the request.

Key Contacts - Other Federal agencies, Congressional delegations, State agencies, State lawmakers, other Forest Service Regions, and heads of organizations were contacted by phone and by letter to inform them of project initiation. Accompanying the letter was an informational brochure describing the scope of the EIS and responding to commonly asked questions.

Risk Assessment - Recognizing that the risk assessment is a technical document with complex thoughts and analysis, postal cards were mailed to all respondents offering them an opportunity to request a draft risk assessment for review. This mailing was done during August and September 1987. About 35 percent of the addresses desired review copies.

Cooperators - No other Agencies requested formal cooperator status, though many were consulted and contributed to the analysis. A unique form of cooperation was implemented for the risk assessment. Other State and Federal agencies as well as several utility companies were offered an opportunity to expand the scope of the risk assessment (to evaluate additional herbicides used by them on their easements or permit areas on national forests). To do this they were required to fund the additional costs of analysis. Eleven utilities and the Tennessee Valley Authority elected to participate.

Responses - Public responses to the request for input on issues were catalogued into nine categories: elected officials; State and local government; Federal government; individuals; organizations; businesses; Forest Service employees; Forest Service retirees; and media. At the time of content analysis, September 1987, 645 responses had been received from 24 states, Puerto Rico, and the District of Columbia. (See table VI-1 for a complete breakdown). Ultimately, the total number of responses was 654.

Of the 645 responses in the table, 593 or 92 percent came from states within the geographic area covered by this EIS Based on a comparison between the number of contacts and number of responses, the most intense response came from Virginia and North Carolina.

Table VI-1.--Response distribution - Appalachian Mountains.

	Category									
State	Elec Off.	St./Loc Gov't	Fed. Gov't	Indi-viduals	Organi-zations	Busi-nesses	Employ-ees	Retir-ees	Media	Total
Alabama		4		44	9	5	3	3	1	69
Arkansas				1	1	2				4
Colorado				1				1		2
Delaware						1				1
Flordia				7	1	1		2		11
Georgia		6	3	34	11	2	7	5	1	69
Illinois				1						1
Kentucky		8		15	7	3	7	1	2	43
Louisiana				1	1	1	1			4
Maryland			1		1	1				3
Massachusetts					1	1				1
Michigan				1			1			2
Minnesota				1						1
Mississippi			2			1	1			4
New York				3		1				4
North Carolina		10		143	15	11	1			180
Ohio				1						1
Oregon				2						2
Pennsylvania			2	1						3
South Carolina		2	1	14	2	3	1	1		24
Tennessee		5	1	37	12	5	9			69
Texas				2	1			1		4
Virginia		9		90	17	9	5	1	2	133
West Virginia			1	1	1	3				6
Puerto Rico							1			1
Washington, DC		2	2		1					3
Total		44	13	400	80	50	37	15	6	645

To improve responsiveness and to enhance the analysis, working papers and partial drafts of many parts of the EIS were shared with cooperating agencies, working groups and citizens with special expertise throughout the process.

Scientific adequacy was ensured through an extensive system of review. Chapter V, D. lists reviewers and their affiliations. Unique qualifications of these people augment disciplines represented on the interdisciplinary team.

Responses were organized into about 150 groups based on methods and affected resources. These groups were then analyzed for major themes called issues (chapter I). Then, a number of alternatives (chapter II) were developed which were responsive to these issues.

The Draft EIS was mailed out for public review on November 30, 1989, with the notice of availability appearing in the Decembe 9, 1988, Federal Register. Copies were sent to each of the 65 respondents, plus others known to have an interest or required by regulations. In all, about 1,800 copies of the Draft EIS and appendices were mailed. About 1,400 copies of the 14-page separately bound summary were also distributed.

The comment period ended February 17, 1989. Comments were accepted at all Southern Region offices in writing, in person, or by phone. Comments received after the February 17 deadline were also fully considered. Comments ultimately totaled 583.

Content analysis was done on the 527 comments received by February 21. Within this total there were two kinds of duplicated or form letters, and one of the comments contained petition signed by several hundred. Each of these was treated as a single comment for content analysis purposes. One form letter was duplicated 17 times, the other, 179 times. These letters are also addressed by a single response in volume III.

Many comments contained several items about issues and aspects of vegetation management. Some expressed a preference for an alternative, often based on perceived effects on a specific environmental element (table VI-2). Some had several items about perceived effects of methods analyzed in the EIS:

No. of Items	Method
443	Herbicides
47	Prescribed Fire
67	Mechanical
65	Manual

Most of these items expressed concern about some unspecified effect (124), but specific concerns were expressed in items about human health (101), wildlife (86), and economics and employment (83).

Of the 527 comments, 57 applauded the quality of analysis an 32 others commented positively about the documents. On the other hand, 32 people criticized the analysis either because was dishonest, used a defective model, or was overdone. Som people also thought the analysis was too complex.

Complete copies of all comment letters are found in volume I

B. CONSULTATION WITH OTHERS

One of the most important parts of the process of preparing this environmental impact statement is information gatherin Advice and contributions from experts are essential to a thorough and complete analysis. Chapter V lists nearly one hundred individuals who contributed. Additionally, in many cases authors of research papers were consulted to clarify results of their analyses.

Table VI-2.--DEIS comments stating an alternative preference

Alternative

Environmental Element	A	Mod A	B	Mod B	C	D	Mod D	E	Mod E	F	Mod F	G	H	None	Favor Manual
Not Specified	15	2	39	5	7	46	3	12	2	38	7	2	2	2	16
Wildlife			1			6				1			1		
T&E			1			1									
Soil			2			1									
Water	1		3		2	3		1		1					
Diversity	3		2			2		1							
Health/Safety	1		2			5				3			1		
Economics		1	2			3		3							
Public Understanding						1									
Multiple Use						3				1			1		

While all consultations helped shape the analysis contained in this document, some consultations resulted in specific significant direction on how to conduct the analysis.

Offices of the Environmental Protection Agency in Atlanta, Georgia and Washington, D.C. were consulted concerning analysis requirements, especially for water. They advised that cumulative effects be analyzed on typical, representative watersheds. They also advised that analysis of sediment loads consider potential effects on quality of fish habitat. The analysis in chapter IV models cumulative watershed effects as advised, and considers effects on fisheries.

Dow Chemical Company was consulted regarding the results of new tests on dermal penetration rates for triclopyr. These test results caused substantial revision of risk assessment.

The contractor responsible for preparation of the risk assessment, Labat-Anderson, Inc., routinely consulted with the Environmental Protection Agency regarding analytical protocol for the risk assessment, and to obtain toxicological information. Data resulting from these consultations are reflected in the risk assessment.

C. LIST OF THOSE TO WHOM THIS DOCUMENT WAS SENT

Businesses

Agricultural Resources Center, Raleigh, NC
American Cyanamid, Agric Div., Wayne, NJ;
  Milwaukee, WI
Appalachian Power Co., Roanoke, VA

Arkansas Land Co., Benham, KY
Arrowhead Starr Co., Plainview, AR
Bath-Alleghany-Rockbridge Coop., Millboro, VA
Bemis Lumber Co, Robbinsville, NC
Big Rivers Electric Corp., Henderson, KY
Bonide Chemical Co., Inc., Yorkville, NY
Boston Edison, Boston, MA
Bowater, Hiwassee Land Company, Calhoun, TN;
  Etowah, TN
Brand's Plummer & Electrician, Alexander City, AL
Buckeye Cellulose Corp., Oglethorpe, GA
Canal Industries, Inc., Lumberton, NC
Carolina Power and Light Company, Raleigh, NC
Central Elec. Power Coop., Inc., Columbia, SC
Central VA Electric Coop., Lovingston, VA
Champion Int. Corp., Century, FL;
Cincinnati Gas & Electic Co., Cincinnati, OH
Clear Creek Camping Park, Burnsville, NC
Cliff A. Logan & Associates, Eutaw, AL
Columbia Gas Transmission Corp., Catlettsburg, KY;
  Charleston, WV
Cullman Electric Coop., Cullman, Al
Davis Bros. Lumber Co., Inc., Richland, SC
Dow Chemical, Indianapolis, IN
Duke Power Co., Charlotte, NC
Eagle's Nest Camp, Pisgah Forest, NC
East Kentucky Power Coop., Winchester, KY
East Tennessee Natural Gas Co., Knoxville, TN
E.I. Du Pont DE Nemours & Co., Wilmington, DE
Elanco Products Company, Greenfield, IN
Engineering Enterprises, Te4lico Plains, TN
Entre Computer Center, Asheville, NC
Fast Draw Frafting, Columbus, GA
David S. Foster, III, Law Corporation
General Control Co., Inc., Tucson, AZ
Habersham EMC, Clarkesville, GA
Hawkins Lumber Co., Grenado, MS
Inland Rome Forestry Division, Inc.
Interntional Paper Co., Mobile, AL
Inter-State Lumber Co., Inc., Bartow, WV
Irland Group, Forestry Consultants, Augusta, ME
Johnston Lumber Co., North Wilkesboro, NC
Kentucky Power Company, Ashland, KY
Kentucky Utilities Co., Lexington, KY
Kimberly-Clark Corp., Lineville, AL
Long Branch Environmental Education Center,
  Leicester, NC
Louisiana-Pacific Corp., Dunsannon, VA
Mead Paper Company, Kingsport, TN
Monsanto Agric. Products Co., Carmel, IN;
  Marietta, GA
Monongahela Power Co., Fairmont, WV
Mountain City Lumber Co., Laurel Bloomery, TN

Nantahala Power and Light Co., Franklin, NC
North American Resource Management, Inc.,
  Charlottesville, VA
N.S.I., Inc., Research Triangle Park, NC
Outward Bound School, Morganton, NC
Ozarks Electirc Coop. Corp., Fayetteville, AR
C. R. Page, Jr. & Assoc., Inc., Chattanooga, TN
Potomac Edison Co., Hagerstown, MD
Powell Valley Electric Coop., Jonesville, VA
Powell Wholesale Lumber Co., Waynesville, NC
Pyxis Resources Co., Wise, VA
Schafer Motor Co., Inc., Orange, VA
Shenandoah Valley Electric C., Dayton, VA
Southern Environmental Law Center, VA, NC
ROWCO, Inc., San Antonio, TX
Taylor-Ramsey Corp., Lynchburg, VA
Tell City Electric Dept., Tell City, IN
Tennessee Consolidated Coal Co, Jasper, TN
Tennessee River Pulp & Paper Co., Counce, TN
Treeplanters, LTD, Willis, VA
Two Brothers Logging Corp., Goshen, VA
Virginia Power, Richmond, VA
V-P, Env. Aff., Columbia Gas, Wilmington, DE
Westvaco Corporation, Appomattox, VA;
  Summerville, SC; Wickliffe, KY
Joe Wheeler Electric Membership Coop., Hartselle, AL
Woodlot Mgmt. Equipment Co., Liberty, NC

Colleges and Universities

Alabama A&M Univ., Normal, AL
Alcorn State Univ., Lorman, MS
Auburn Univ., Auburn, AL
Clemson Univ., Clemson, SC
Delaware State College, Dover, DE
Florida A&M Univ., Tallahassee, FL
Fort Valley State College,, Fort Valley, GA
Harvard Univ. Business School, Boston, MA
Humboldt State Univ., Arcata, CA
Kentucky State Univ., Frankfort, KY
Langston Univ., Langston, OK
Louisiana State Univ., Baton Rouge, LA
Louisiana Tech Univ., Ruston, LA
Mississippi State Univ., Mississippi State, MS
North Carolina A&T State Univ., Greensboro, NC
North Carolina State Univ., Raleigh, NC
NSU, Natchitoches, LA
Oklahoma State Univ., Stillwater, OK
Prairie View A&M Univ., Prairie View, TX
Roanoke College, Salem, VA
Rust College, Holly Springs, MS
Slippery Rock State College, Slippery Rock, PA

South Carolina State College, Orangeburg, SC
Southern University, Baton Rouge, LA
Stephen F. Austin Univ., Nacogdoches, TX
Tennessee State Univ., Nashville, TN
Texas A&M Univ., College Station, TX
Tuskegee Institute, Tuskegee Institute, AL
University of Alabama, Tuscaloosa, AL
University of Arkansas, Pine Bluff, AR;
  Fayetteville, AR
University of Florida, Gainesville, FL
University of Georgia, Athens, GA
University of Houston, Houston, TX
University of Kentucky, Lexington, KY
University of Maryland-Eastern Shore, Princess Anne, MD
University of Pittsburg, Pittsburg, PA
University of Southern Mississippi, Hattiesburg, MS
University of Tennessee, Knoxville, TN
University of Wisconsin, Madison, WI
Virginia State Univ., Petersburg, VA
VPI & State Univ., Blacksburg, VA
Western Carolina Univ., Collowhee, NC
West Georgia College, Carrollton, GA
West Virginia Univ., Morgantown, WV
Yale Law School, New Haven, CN

Elected Federal Officials

Alabama
- Howell Heflin
- Richard C. Shelby
- Tom Bevill
- Sonny Callahan
- Bill Dickinson
- Ronnie Flippo
- Claude Harris

Georgia
- Wyche Fowler, Jr.
- Sam Nunn
- George Darden
- John Lewis
- Ed Jenkins

Kentucky
- Wendell H. Ford
- Mitch McConnell
- James Bunning
- Larry J. Hopkins
- Carroll Hubbard
- Romano L. Mazzoli
- William H. Natcher
- Carl C. Perkins
- Harold Rogers

North Carolina
- Jesse Helms
- Terry Sanford
- Cas Ballenger
- James McClure Clarke

South Carolina
- Ernest F. Hollings
- J. Strom Thurmond
- Butler C. Derrick,Jr.
- Arthur Ravenel, Jr.

Tennessee
- Albert Gore
- Jim Sasser
- John Duncan
- Marilyn Lloyd
- James H. Quillen

Virginia
- John W. Warner
- Charles S. Robb
- Frederick C. Boucher
- James R. Olin
- L. F. Payne
- D. French Slaughter, Jr.

West Virginia
- Robert C. Byrd
- John D. Rockefeller,
- Harley O. Staggers,

Federal Agencies

Advisory Council Historic Preservation, Washington, DC
Delaware River Basins Comm., West Trenton, NJ
Department of Agriculture
  Animal & Plant Health Ins. Serv., Hyattsville, MD
  Forest Service, Albuquerque, NM; Atlanta, GA; Broomall, PA;
    Lakewood, CO; Ogden, UT; Milwaukee, WI; Missoula, MT;
    Portland, OR; San Francisco, CA
  Gov. & Public Affairs, Washington, DC
  Office of General Counsel, Ogden, UT
  Office of the Secretary, Washington, DC
  Rural Electrification Admin., Washington, DC
  Soil Conservation Service, Fort Worth, TX; Mt. Vernon, KY;
    Washington, DC
Department of Defense
  Corps of Engineers, Wilmington, NC; Washington, DC, Asheville, NC
Department of Health and Human Service
  CDC, Atlanta, GA
Department of Interior
  Bureau of Land Management, Alexandria, VA; Jackson, MS
  Bureau of Mines, Washington, DC; Denver, CO
  Director, Environmental Project Review, Washington, DC;
    Albuquerque, NM
  Fish & Wildlife Service, Atlanta, GA;
    Annapolis, MD; Daphne, AL; Cookeville, TN;
    DFW Airport, TX
  Geological Survey, Tuscaloosa, AL
  Great Smoky Mountains National Park, Gatlinburg, TN
  Horseshoe Bend National Park, Daviston, AL
  National Park Service, Appalachian National Scenic Trail,
    Harpers Ferry, WV;
    Louisville, KY; Philadelphia, PA; Tupelo, MS;
  Office of Environmental Project Review, Atlanta, GA
    Washington, DC; Blue Ridge Parkway, Asheville, NC
Department of Transportation
    Office of the Secretary, Environmental Division,
    Washington, DC
Federal Highway Administration, Atlanta, GA;
    Baltimore, MD; Baton Rouge, LA; Columbia, SC;
    Fort Worth, Texas; Tallahassee, FL
  Forest Systems Development, Washington, DC
  Asst. Secretary for Policy & International Affairs,
    Washington, DC
Interstate Commerce Commission, Washington, DC
Environmental Protection Agency
  Atlanta, GA; Washington, DC; New York, NY;
  Review Coordinator, Philadelphia, PA; Dallas, TX
FDA (HFF-304)
Federal Energy Regulatory Comm., Washington, DC
Federal Railroad Administration, Washington, DC
Great Smoky Mountain National Park,
  Gatlinburg, TN

National Fish Hatchery, Walhalla, SC
National Marine Fisheries Serv., St. Petersburg, FL
National Oceanic & Atmospheric Administration &
  Conservation Div., Washington, DC
Nationwide Forest Planning Clearinghouse, Eugene, OR
Nuclear Regulatory Comm., Atlanta, GA
Occupational Safety & Health, Washington, DC
Office of Env. Proj. Rev., Atlanta, GA
  Regional Environmental Officer, Philadelphia, PA;
  Washington, DC
Small Business Administration, Atlanta, GA
Soil Conservation Service, Nashville, TN
Tennessee Valley Authority, Knoxville, TN; Norris, TN;
  Golden Pond, KY

Individuals

Abernethy, Vivian F.
Adams, Carl
Adams, David A.
Alexander, W. H.
Alfiero, Richard
Alger, Nellie M.
Allen, Leighton
Allen, Paul B., Jr.
Allen, Ronald L.
Alley, James R.
Allison, Jane M.
Alsop, Fred
Amundsen, Clifford C.
Anderson, B. K.
Anderson, Bill
Anderson, C. E.
Anderson, Joane & R.E.D.
Anderson, Robert L.
Antonie, Glenn O.
Araman, Philip A.
Arias, Sheila
Arney, Ken
Arnold, Alice
Arrowood, Michael
Athos, Debbie
Austin, Harold
Aziz, Bernadine
Bailey, Thomas W., Jr.
Bain, Mike
Balmer, Bill
Baltic, Tony
Barber, Harold
Barbory, Karen
Bard, George L.
Barden, Charles J.
Barker, Milton E., Jr.
Barnette, Phil
Barrett, Morley W.
Barrett, Willie W.
Bartgis, Rodney
Battle, Patryk B.
Bass, Stuart
Beeler, Leslee
Beier, Charles J., Jr.
Benedict, S. S.
Benko, Roger
Bennett, Howard D.
Bent, Samatha T.
Berry, Jerri A.
Berry, Mr. & Mrs. Jerry L.
Birch, Harold B.
Black, Lester
Blackburn, Makie
Bland, Mark A.
Bledsoe, Bobby W.
Bohres, Gertrude
Boland, Peg
Bolden, Charles K.
Bolgiano, Christina
Bonds, W. A.
Bonner, W. R.
Boone, Dan
Booth, Carl
Bove, Diane
Bowers, Amy S.
Bowers, Mary Ann
Brady, Charlotte L.
Bradley, Craig J.
Braham, Richard R.
Brewer, Audra
Breyfogle, Samuel W.
Brooks, R. C.
Brooksher, Edward C.
Broster, Charlie
Brown, Christine
Brown, F. K.
Brown, Gaines M.
Brown, John M.
Brown, Les
Brumm, Bill
Brunell, Arnold M.
Bruner, Marlin H.
Bruni, Roberto C.
Bryant, Glenn Dale
Buckner, Garren
Burbank, James H.
Burdett, Allen M.
Burkart, Dave
Burns, Marvin
Burris, Bill O.
Butler, Elmer
Byrd, Joan F.
Byrne, John J.
Cairens, Warren G.
Caldwell, Edward & Shaw, Na
Cameron, Douglas W.
Campbell, R. L.
Campbell, Woodrow
Canode, Sam
Cantrell, Rick L.
Carey, Robert
Carlton, Bruce
Carlyle, Sue W.
Carpenter, Cindy
Carpenter, Janella Ann
Carter, David C.
Carter, Jon

Carter, Robert E.
Carter, Tim
Cash, William B.
Casey, Susan
Cason, John F.
Cathey, Samuel B.
Caupp, Greg
Cauthen, Campbell
Chandler, Cheryl
Chapman, Pat
Charton, Pete
Chatman, Frank
Childress, Cheryl P.
Childress, Eric
Chrisholm, Judy S.
Christiansen, Jane
Cima, Joseph A.
Clark, Bob & Elizabeth
Clark, Eddie
Clarke, Bruce B.
Clarke, Mrs. William E.
Clement, D. A.
Clifford, Hester F.
Clonts, Howard A.
Coates, Brenda
Cody, Donna K.
Cody, Jim L.
Coleman, W. Tredway
Collins, James A.
Colona, Robert T.
Colvard, Mrs. Sandra
Colvin, Barbara
Cone, John P., Jr.
Conner, Bob & Elizabeth
Conroy, William Peter
Cook, Heloise B.
Cooke, Bob
Coon, Richard P.
Cooper, David E.
Cooper, Jerome A.
Cornelius, Don
Cornelius, Elizabeth
Couch, Clara R.
Cowan, Mary Lou
Cowan, Robert J.Cowger, Dabney H.
Cox, Dorothy
Coyner, Peyton
Crabtree, John S.
Craig, Elizabeth
Cristman, Steve
Croom, JoAnn T.
Crothers, Ron
Crowe, Sharon
Crumbley, Lamar

Culbreth, John R.
Culpepper, Mrs. Floy
Cunningham, John D.
Currence, Charles W.
Cutler, Anne H.
Dahlke, David C.
Dale, Edwin
Daly, Ed
Dauphine, David
Davidson, Gilbert
Davis, Ira Mae
Davis, Kenneth L.
Davis, Michael J.
Dawson, James C.
DeBona, Donald J.
Deeds, R. H.
Deel, Grayson L.
Deen, Delano
Delbert, Barbara
Delbert, Greear P.
Dempsey, Samuel
Denise, Mrs. Billie
DeRossi, Henry & Cindy
Devlin, Daniel A.
Deyo, Robert G.
Dickson, Catherine
Dixon, Rodney A.
Doerschuk, Jeanne B.
Dorn, Betsy
Doss, Martha S.
Downing, Robert L.
Dunlap, Ron
Dickson, James
Drumheller, Philip M.
Dudley, George W.
Duncan, Charles F.
Dunlap, Ron
Dunn, Samuel J.
Dunn, Thomas L.
Duvinage, Thelma C.
Edwards, Malcolm
Edwards, Sandra
Eglington, Dana
Ells, Michael
Elsner, Norman R.
Emery, Edith A.
Emmons, Kirk
Engle, Edward F.
Essic, James E., Jr.
Eurey, C.
Evans, Kent E.
Evans, Richard
Faherty, Catherine
Faherty, Dr. John C.

Fatora, Elaine
Faulconer, Sarah P.
Faw, Michael D.
Fearrington, C. W.
Feasel, R. C.
Feinberg, Lizabeth D.
Feldman, Richard S.
Ferullo, Patricia
Fickel, Ralph
Fieselman, John
Floyd, H. M.
Folsom, Todd C.
Forbes, Brenda S.
Ford, Fannie Lee
Formwalt, Elizabeth W.
Formwalt, John
Foster, Grace
Fowler, Dale
Frady, Porter R.
Frampton, John
Francies, Gary
Franza, A. C.
Frazier, Ronnie L.
Fredericksen, Todd S.
Freeland, George
Friedman, Arthur
Friedrich, Allan
Frost, Cecil C.
Fulmer, Frank E.
Gandy, Betsy
Garbarino, Ed & Melba
Garber, Vernon
Garrison, Lynn
Gatti, Tom
Gaylord, Mary Caroline
Gerhardt, Alvin & Sally
Gerry, Bob
Gibbs, George S.
Gillen, John L.
Gillenwater, Johnny R.
Gilmour, Monroe T.
Gingrich, Richard
Gitlin, Sharon J.
Gobble, Paul
Godden, B. W.
Goldenthal, A. J.
Gowin, Charles A.
Graham, Ted A.
Grant, Deborah & Charles
Gray, Becky & Kennedy, Richard
Gray, John D.
Greear, Delbert
Green, Timothy Patrick
Greene, Bruce

Greeter, Stuart E.
Gregas, Norman P.
Greth, Donald D.
Griffith, Edith M.
Griswold, Ron
Grobowski, James E.
Groz, Becky
Hale, Asa
Hall, Elmer D.
Hall, Marjorie
Hall, Norma F.
Hallahan, Fran
Hambrick, John S.
Hamby, Lloyd
Hamel, Paul
Hammett, Doris Bixby
Hammond, Crickett
Hanson, Judy
Hanson, Linda L.
Harberts, Dr. Athrur S.
Hargett, Gil
Harrell, June D.
Hartford, Winslow H.
Harvey, Kenneth V.
Harwood, Anita J.
Hatcher, Jane
Hattaway, Melvin A.
Hayes, Lynn E.
Hayes, Mrs. E. Paul
Hazzard, Ann G.
Heath, Milton
Hembree, Charles R.
Hendrickson, James D.
Hensley, James Arthur
Herrig, Jim
Heywood, Richard
Hibbard, Jack
Hicks, Wilma
Hight, M. E.
Hilbers, C. L.
Hill, James H.
Hill, Travers
Hindman, Douglas
Hines, Richard E.
Ho, Mengchi
Hodges, Carolyn Gay
Hodges, Loretta
Hodges, Thomas L., Jr.
Hoell, Francie & Joey
Hoelscher, James E., Jr.
Hollend, Tina
Hollifield, Clyde
Hood, Cliff H.
Hopkins, Herbert G. & Sara B.
Hopkins, Walt
Hoppes, Bill
Hopton, Patrick A.
Horakova, Zoenka Z.
Horn, David
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Howard, H. E.
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Hutchinson, Bruce
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Jacobs, Elmer R.
Jacobsen, J.
Jaggers, Herman
Janosik, Steve
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Jennings, Richard G., Jr.
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Johnson, Curt
Johnson, Gilbert C. & Joyce D.
Johnson, Glenn N.
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Johnson, Mary L.
Johnson, Dr. Patricia J.
Johnson, Robert
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Jones, Agnes
Jones, Eli, Jr.
Jones, J. V.
Jones, Margaret Rose
Jones, Myra H.
Jordan, Albert
Joslin, Ruth
Jump, Bill
Jurgelski, Annette E.
Karpen, Leah
Kauffmann, Karl
Kearney, Lewis
Kelley, J. David
Kent, Phillip T.
Kerschner, Jean
Kettenbeil, Don H.
Kinard, Fred
Kindt, Warren F.
King, Clarence F., Jr.
Kinney, Norm
Kirkham, Ken
Kitler, Steven J.
Kitson, Terry R.
Knoedler, Albert Paul
Knowles, Brian D.
Kohinke, Edward G., Sr.
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Kolenbrander, Larry
Koller, Norman F.
Kosticky, John S.
Kovalic, Peter P.
Kreger, Allen
Krouse, Marlin
Kushner, Adele
Kutack, Jason N.
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Langsner, Drew
Langsner, Louise
Lanston, Stephen A.
Larwood, Mason B.
Lasher, Peggy
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Law, Steve
Legrand, Mary E.
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Lindsey, Treska
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Linscott, Lester L.
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Little, Janea M.
Livesay, Marcia W.
LoBean, Allen
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Louallen, Ricky J. E.
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Loven, C. W.
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Lyday, Robert L.

Lynch, George D.
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MacCorkee, Frances
Maltbie, Dorothy P.
Manley, Leo H.
Mann, Mr. & Mrs. M. J.
Mansfield, Ellen & John
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Martin, Bobby Steven
Martin, Cheryl L.
Martin, James F.
Martin, William H.
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Mason, Roberta
Masterson, Stephanie K.
Matheson, Tim J.
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Maxson, Charles W.
Maxson, Mrs. Julia K.
Mays, James David
Mazzina, Quinta
Mazzola, J.
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McCold, Lance
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McComb, Terry K.
McConnell, Chester
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McDowell, Gladstone W.
McFarlane, R. M.
McFee, Joe M.
McFee, Michael & Belinda
McGahey, Robert G.
McGlwee, R. L.
McHugh, James
McIntosh, Levonne
McIntyre, James F.
McJunkin, Noel P.
McLean, Joan S.
McLeod, Don
McMahon, Charles K.
McNeal, Leonard J.
McWhirter, Loy
Mead, James & Ruth
Meadows, Mrs. Robert L., Jr.
Melamut, Steven J.
Mengak, Michael T.
Merrell, Bob
Metzger, E. Harrison
Metzger, Paul S.
Michael, Ed
Michael, Eswin D.
Michael, Jerry
Mielke, Lewis H.
Miles, Dan
Millar, Richard H.
Miller, Bruce L.
Miller, Charles A.
Miller, Michael A.
Miller, William R.
Mills, Tom
Minckler, Leon S.
Mitchell, Laura J.
Mohney, Sharon E.
Moore, John W.
Moore, Rodne D., II
Moore, Vicki L.
Moorefield, William G.
Morgan, Betsy
Morgan, Jenifer Ann
Morales, Rose M.
Moroshok, S.
Morrell, Ernest E.
Morrill, William
Morris, John
Morriss, Donald
Morton, Hugh
Morton, Richard
Moss, Robert
Mrazek, Bill & Lynda
Mueller, Robert F.
Muller, John H.
Muncy, Jack
Murphy, Daniel A.
Murphy, Sue A.
Murray, James R.
Murray, Judy
Myers, David N.
Myers, J. Walter, Jr.
Nace, Douglas P.
Neary, Dan
Neely, William M.
Nelson, Earl & Janice
Nelson, Francine D.
Nelson, John
Nettles, Diane P.
Neville, William G.
Newman, Michael
Niemi, Douglas C.
Nixon, Christopher F.
Nixon, Nathan
Novotny, E. G
Nuthall, Beatrice T.
Nutt, David C.
Oberhausen, Marilyn & David
O'Brien, Suzanne K.
O'Toole, Randall
Odom, Richard H.
Ogle, Douglas W.
Ohle, Elpenor R.
Ohle, Elisabeth E.
Olsen, Sherman A., Jr.
Orr, E.
Orr, Patricia
Orselli, Janet T.
Osborn, O. Wells
Osborne, Kimberly A.
Overbey, F. T.
Owen, Donald
Pace, Don A.
Padgett, James R.
Padgham, Jon
Palmer, Dr. James F.
Paris, Lamar
Parish, Thurman
Parker, Elizabeth G.
Parker, James A.
Partee, Evelyn
Paschal, Lawrence W., Jr.
Patterson, Ms. Perry
Paulick, Diana M.
Pearlman, Jon and Aileen
Pearson, Henry A.
Pennington, Roy M.
Petelle, Michael
Pfeil, Jay
Pharr, Ann L.
Phillips, Larry N.
Phillips, T. G.
Pielke, R. A.
Pierce, Mr. & Mrs. Lawrence
Plockelman, Dianne L.
Ploetz, Bob
Polansik, Stanley J.
Poole, Ray V.
Pope, D. D.
Poteat, Jason A.
Pratali, Pat
Prewitt, Terrell G.
Pruitt, Jim
Punch, Jaquetta R.
Ramesytown Township Concerned Citizens
Ramey, James W.
Ramsey, Faye G.
Rankin, Douglass E.

Rankin, Jimmy
Rapp, Michael W.
Rawson, Jim
Ray, Blaine
Reed, Derik
Reese, Francis X., S.J.
Reimensnyder, Barbara
Retan, J. Walden
Revis, Ruby J.
Rice, Mrs. Charles M.
Richards, Paul W.
Richardson, Donnie M.
Ririe, Warren
Roberts, Joseph W.
Roberts, Lucile R.
Roberts, Marjorie & George
Robertson, R. S.
Rodgers, Elizabeth B.
Rodriguez, Lorraine
Roe, Eugene
Rogers, Lindsey
Rogers, Vera B.
Rogers, Weaver B.
Roland-Parrish, Hattie
Roth, Pauline
Rouse, Debbie
Rowe, Jane Ashford
Rowland, Dr. Paul
Ruggles, Will
Ruhl, Susan T.
Rule, Walter, Jr.
Rusnak, Irene
Russell, Samuel W.
Ryan, Bob
Ryan, William Walter
Sabin, Jim
Sanborn, Herbert J.
Sanderford, Mrs. Eloise
Sarchez, James
Savage, Ann H.
Scatena, Frederick N.
Scheckel, Judy
Schell, Edward
Schemnitz, S. D.
Scherer, Michael
Schmidt, D. M.
Schneider, Rachel G.
Schoepfle, Gordon M.
Schrader, Walt
Seay, Thomas N.
Sechrest, Rhonda
Seelbach, Carol Lani
Seriff, Don
Shackelford, Nevyle
Shafer, Alice P.
Shankman, David
Sheffer, Dale E.
Shelton, Gordon W.
Shelton, Michael G.
Shelton, Philip C.
Sherrill, Jack
Shirley, Mrs. Griffin
Shobe, Sandy
Shope, G. E.
Shreffler, Jack
Shriner, Robert F.
Silver, Marguerite M.
Simon, Dean M.
Simons, Walter
Sims, Jared P.
Sizer, Pullen
Skelton, Will
Skidmore, Jim
Slifer, Dennis
Sloane, Gordon B.
Smith, Alan
Smith, Annie Dee L.
Smith, Clay
Smith, Herrick H.
Smith, James M.
Smith, Mr. & Mrs. William S.
Smith, Dr. Gary
Smith, Robert W., Jr.
Smith, Walton R.
Smithers, Charlie
Sonder, Edward
Spatcher, David L.
Spiller, Donald D., Jr.
St. John, Roy E., Jr.
Stage, Dr. John T.
Stage, Shirley E.
Stamper, C. M.
Stamper, Peggy G.
Stanback, Bradford G.
Stanley, Roman C.
Stansell, Dennis
Steedley, Arthur G.
Steenburgh, E. W. Van
Steensen, Donald H. J.
Stephens, Robert E.
Stephens, David L.
Stephenson, Joey
Stewart, Joy
Stewart, Sherwood A.
Still, Hugh R.
Stout, Jack
Stradt, Gilbert S.
Stumbo, Don
Sudderth, Joy E.
Summerour, Bill
Svensson, Audrey
Svensson, E. S., Jr.
Swanson, John R.
Symonds, Dorothy H.
Taylor, Creed, Jr.
Taylor, G. C. & Speck, R. R.
Taylor, Jack L.
Taylor, Joe
Taylor, Nelson
Taylor, Richard W.
Teague, Mrs. Perri
Testa, Arthur R.
Thibodeau, Patricia L.
Thigpen, P. L.
Thomas, Jo Ann
Thomas, William R., Jr.
Thompson, Julius E.
Thompson, Maurice
Thompson, Thomas L.
Thorn, Jerry
Thorne, Mrs. W. H.
Thornley, Ethel
Thorsen, Jim
Thornton, Richard P.
Thrash, Thomas L.
Thurmond, Charles
Tilson, Jerry B.
Tippett, Candace
Todd, James R., Jr.
Toms, Helen E.
Toms, Tommy
Trauger, David
Tremege, Jacques
Trively, Maxine Churchill
Troxler, George & Carole
True, M. G.
Tucker, Ed
Tucker, Ronda
Turner, Chris D.
Udry, J. R.
Umholtz, Mrs. John L.
Valentine, Dorothy P.
Van Brasner, Jim
Van Lear, David
Van Sickle, Charles C.
Vanover, Jerry W.
Varner, Johnnie B.
Vest, Brenda
Vest, Elmer
Vigerstad, Torgny
Vinovich, Robin
Vinson, Kathy

Wagner, Carl C.
Wagner, Robert E.
Waldroop, Ethel M.
Waldrop, Tom
Warren, Ririe
Warren, Roger
Warren, Robert J.
Warren, Susan
Weeks, Brad
Weeks, William P.
Weisner, William W.
Welch, Melvin
Welles, Richard H.
Wells, Dewey W.
West, Earl & Barbara
Wharton, Charles
Wheeler, David
Whitefield, Anne
Whitmer, Herbert, Jr.
Wicker, Leo & Genia
Wieboldt, Thomas F.
Wiedman, Susan H.
Wiedman, Louise N.
Wiener, Bill, Jr.
Wilcher, John W.
Wilcox, James B.
Williams, Alva B.
Williams, Earle D.
Williams, Mary Ann
Wilson, Shannon E.
Wilson, Allen R.
Wilson, Mr. & Mrs. J. Mack
Winton, Douglas E.
Wisnoski, Suzanne
Wofsy, Sheila
Wolfe, Karen L.
Wojtalik, Tom
Wood, Darry
Wood, Rebecca J.
Woods, David
Wright, Harry R.
Yankey, Allen G.
Yost, Sandra T.
Young, Harold E.
Youngblood, Gary
Zimmerman, Fred & Sarah
Zimmerman, Laura L.
Zimmerman, Jennifer L.
Zumwalt, Jim

Libraries

FSL Library, Westvaco, Summerville, SC
International Paper Co., Librarian, Bainbridge, GA
J. G. Crabbe Library, KY
National Agricultural Library, Beltsville, MD
Southfornet, Athens, GA
The Libraries, Colorado State Univ., Ft. Collins, CO
Westfornet, Ft. Collins, CO; Ogden, UT; Seattle, WA
Weyerhaeuser Co, Library, Centralia, WA, Hot Springs, AR

Media

Asheville Citizen Times, Asheville, NC
Franklin Press, Franklin, NC
John Harmon, Blairsville, GA
Lexington Herald, Lexington, KY
Mountain Times
Richmond Times Dispatch, Charlottesville, VA
The Anniston Star, Anniston, AL
The Panogram, Ownesboro, KY
WDOC-AM/FM, Prestonsburg, KY
WINC Radio, Winchester, VA
WTVC, Chattanooga, TN

Minority Organizations

Black Chamber of Commerce, Texarkana, AR
Caddo Executive Committee, Binger, OK
Cheyenne-Arapaho Bus. Comm., Concho, OK
Chitimacha Tribal Council, Charenton, LA
Citizen Potawatomi Bus. Comm. Shawnee, OK
Creek National Office Oklahoma, Okmulgee, OK
Eastern Band of Cherokee Indians, Cherokee, NC
Houston Area Urban Leagues, Houston, TX
NAACP, Atlanta, GA; Columbia, SC; Charleston, SC
  Tallahassee, FL
National Urban League, Atlanta, GA
NW Univ. Center for Urban Affairs, Evanston, IL
OIC Opportunity Industrial, Atlanta, GA
OTOE-Missouria Bus. Comm., Red Rock, OK
Pawnee Business Council, Pawnee, OK
Quapaw Tribal Bus. Comm., Quapaw, OK
Tonkawa Business Comm., Tonkawa, OK

Organizations

American Camping Assoc., Martinsville, IN
Alabama Conservancy, Anniston, AL; Birmingham, AL;
  Selma, AL
Alabama Ornithological Society, Birmingham, AL
American Farm Bureau Federation, Park Ridge, IL
American Forest Council, Atlanta, GA
American Motorcycle Assoc., Westerville, OH

American Orchid Society, West Palm Beach, FL;
Pensacola, FL
American Petroleum Institute, Washington, DC
American Plywood Assoc., Atlanta, GA
American Pulpwood Assoc., Jackson, MS
American Society of Landscape Arch., Washington, DC;
Atlanta, GA
Appalachian Consortium, Inc., Boone, NC
Appalachian Trail Conference, Atlanta, GA;
Asheville, NC; Harpers Ferry, WV
Arkansas Forestry Assoc., Little Rock, AR
A.S.P.I, Livingston, KY
Audubon Society, Atlanta, GA; Asheville, NC;
Birmingham, AL
Beaver Creek Sportsman Club, Corbin, KY
Boone Area Chamber of Commerce, Boone, NC
Bowhunters of Alabama, Courtland, AL
Carolina Mountain Club, Hendersonville, NC
Cherokee Scouts, Murphy, NC
Common Sense Army, Etowah, TN; Reliance, TN
Cons. for Federated Clubs, Moulton, AL
Cumberland Stream Fishing Assoc., Nashville, TN
Earth First, Tucson, AZ
Eighth District Wildlife Fed. Rush, KY
Elachee Nature Science Center, Gainesville, GA
Elisha Mitchell Audubon Society, Asheville, NC
Environmental Law Institute, Arlington, VA
Forest Farmers Association, Atlanta, GA
Forest Industries Assoc., Corbin, KY
Forest Service Timber Purchasers Council, New Orleans, LA
Forest Voices, West Jefferson, NC
Friends of the Mountains, Tiger, GA; Toccoa, GA
Friends of the Watauga River, Sugar Grove, NC
Garden Club of America, Atlanta, GA
Georgia Appalachian Trail Club, Atlanta, GA
Georgia Natural Heritage, Social Circle, GA
International Forestsearch Ltd, Prince Albert, Saskatchewan
Izaak Walton League of America, Arlington, VA; Morristown, TN
Louisiana Forestry Association, Alexandria, LA
Lumber River Basin Comm., Lumberton, NC
Madison County Env. Def. League, Mars Hill, NC
McCreary County Hiking Club, Struck, KY
Mountain Valley RC&D C., Waynesville, NC
National Assoc. of Conservation District, Athens, GA
National End. for the Arts, Washington, DC
National Forest Products Assoc., Washington, DC; Atlanta, GA
National Wildlife Federation, Atlanta, GA;
Washington, DC
National Wild Turkey Federation, Edgefield, SC
Nature Conservancy, Arlington, MA
NC Environmental Defense Fund, Raleigh, NC
NC Nature Conservancy, Carrboro, NC
NC Wildlife Federation, Shelby, NC
NC Wild Trukey Federation, Troy, NC
Office of Equal Opportunity, Washington, DC
Piedmont Environmental Countil, Warrenton, VA

Public Awareness Committee, Fort Smith, AR
Rabun Co. Chamber of Commerce, Clayton, GA
Returning Buffalo Medicine Society,
  Birmingham, AL
Rowan County Wildlife Club, Morehead, KY
Shoals Chapter Alabama Conservancy
Sierra Club, Sheffield, AL; Athens, GA;
  Atlanta, GA; Richmond, KY;
  Chevy Chase, MD; Boiling Springs, NC,
  Morganton, NC, Shelby, NC, Winston-Salem, NC;
  Charleston, SC; Knoxville, TN; Pearland, TX;
  Nellysford, VA; Richmond, VA
Smoky Mountain Acres Owners Assoc., Palm Bay, FL
Smoky Mountains Hiking Club, Knoxville, TN
Society of American Foresters, Bethesda, MD
Southeastern Assoc. of Fish & Wildlife, Tallahassee, FL
Southeastern Fisheries Council, Fort Collins, CO
Southeast Region of YMCA, Atlanta, GA
Southern Appalachian Highlands Conservancy, Kingsport, TN
Southern Growth Policies Board, Research Triangle Park, NC
Southwestern NC RC&D Area, Waynesville, NC
Tennessee Eastman Hiking Club, Kingsport, TN
Tennessee Farm Bureau Federation, Columbia, TN
The Baldkeepers, Hayesville, NC
The Nature Conservancy, Chapel Hill, NC
Trout Unlimited, Chattanooga, TN; Fishersville, VA
  Rabun Gap, GA; Richmond, VA; Roanoke, VA; Vienna, VA
Virginia Bear Hunter's Assoc., Timberville, VA
Virginia Citizen for Better Reclam., Norton, VA
Virginia 4x4 Association, Mechanicsville, VA
Virginia Four Wheel Drive Association
Virginia Wild Turkey Federation
Virginia Wilderness Committee, Lexington, VA;
  Swoope, VA; Winchester, VA
Virginia Wildlife Federation, Alexandria, VA
Vulcan Trail Association, Birmingham, AL
Watauga Audubon Society, Kinsport, TN
Western NC Alliance, Franklin, NC; Sylva, NC;
  Asheville, NC
West Kentucky Chapter SAF, Golden Pond, KY
Wilderness Commission, Lexington, VA
Wildlife Management Institute, Dripping Springs, TX

State and Local Government - Alabama

Cooperative Extension Service
Department of Conservation
Department of Environmental Mgmt.
Forestry Commission
St. Clair County Board of Education

State and Local Government - Arkansas

Cooperative Extension Service
Forestry Commission
Historic Preservation Prog.

State and Local Government - Florida

Cooperative Extension Service
Division of Forestry

State and Local Government - Georgia

Cooperative Extension Service
Department of Natural Resources
Department of Transportation
Forestry Commission
Limestone Valley RD&D Council
Natural Heritage Inventory
Regional Extension Forester
Soil District Supervisor
Towns County Extension Service

State and Local Government - Kentucky

- Cooperative Extension Service
- Commonwealth of Kentucky
  - Department for Environmental Protection
    - Division of Water
  - Department for Natural Resources
    - Division of Forestry
  - Division of Fish & Wildlife Resources
- Environmental Quality Comm.
- Pulaski County Extension Service
- Representative, Adrain Arnold
- Representative, Walter Blevins, Jr.
- Representative, Dann R. Ford
- Representative, Mae Hoover
- Representative, Stephen C. Keith
- Representative, Pearl Ray Lefevers
- Representative, Jim Maggard
- Representative, Paul Mason
- Representative, Roger Noe
- Representative, Clarence D. Noland
- Representative, Paul W. Richardson
- Representative, Albert Robinson
- Representative, Charles L. Siler
- Representative, Tommy Todd
- Representative, Caroline White
- Representative, Pete Worthington
- Senator, Benny Ray Bailey
- Senator, John D. Rogers
- Senator, John A. Rose
- Senator, Landon C. Sexton
- Senator, Gene Huff
- Senator, Woody May
- Senator, David L. Williams
- State Clearing House

State and Local Government - Louisiana

Cooperative Extension Service

State and Local Government - Maine

Department Inland Fisheries & Wildlife

State and Local Government - Maryland

Cooperative Extension Service

State and Local Government - Minnesota

Department of Natural Resources
Minnesota Landscape Arboretum

State and Local Government - Mississippi

Cooperative Extension Service
Forestry Commission

State and Local Government - New Jersey

Department of Environmental Protection

State and Local Government - North Carolina

Blue Ridge Parkway
Burke County Environmental Health
Cooperative Extension Service
Department of Agriculture
Department of Cultural Resources
Department of Natural Res. & Comm. Dev.
Department of Transportation, Planning & Research
Division of Recreation & Parks
Elbert Felton
Environmental Management Commission
Haywood County Planner
Land-of-Sky Regional Council
Natural Heritage
State Historic Preservation Office
Town of Beech Mountain, NC
Town of Boone, NC
Town of Canton, NC
Vance Birthplace State Historic
Wautauga County Planning Director
Wildlife Resources Commission

State and Local Government - Oklahoma

Extension Forester
Forestry Division

State and Local Government - South Carolina

Carroll Campbell, Governor
Department Health & Env. Control
Forestry Commission
Wildlife & Marine Resources Department

State and Local Government - Tennessee

Cooperative Extension Service
Department of Conservation
Department of Forestry, Wildlife & Fisheries
Department of Health and Environment
Division of Forestry
Ecological Service Division
First Tennessee Development District
TWRA
Unicoi County Assessor's Office
U. T. Agric. Extension Service
Wildlife Resources Agency

State and Local Government - Texas

Committee on Natural Resources
Cooperative Extension Service

State and Local Government - Virginia

Bureau of Plant Protection
Central Shenandoah Plan. Dist. Comm.
Central Virginia Planning Dist. Comm.
City of Harrisonburg
Clay County Board of Commissioners
Commission of Game & Inland Fisheries
Commonwealth of Virginia
Cooperative Extension Service
County Administration
Culpeper County Planning & Zoning
Department of Air Pollution Control
Department of Conservation & Historic Resources
Department of Forestry
Department of Health
Department of Natural Resources
Department of Waste Management
Fifth Planning District Commission
Forestry Commission
Grayson County
Roanoke Co. Planning & Zoning
Secretary of Natural Resources
State Administrator
State Water Control Board

State and Local Government - West Virginia

Department of Natural Resources

CHAPTER VII

Glossary

CHAPTER VII

GLOSSARY

Active ingredient (a.i.).--The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

Acute toxicity.--The toxicity of a compound when given in a single dose or in multiple doses over a period of 24 hours or less. The quality or potential of a substance to cause injury or illness shortly after exposure to a relatively large dose.

Adjuvant-additive.--Something added to the pesticide mixture to help the active ingredient do a better job. Examples: wetting agent, spreader, adhesive, emulsifying agent, penetrant.

a.i.--See Active ingredient.-

Allelopathic.--Pertaining to the suppression of growth of one plant species by another through the release of toxic substances.

Amine.--Any of a group of organic compounds of nitrogen, such as ethylamine, $C_2H_5NH_2$, that may be considered ammonia derivatives in which one or more hydrogen atoms have been replaced by a hydrocarbon radical.

Animal unit month (AUM).--The amount of feed or forage required by an animal unit for one month.

Annual (plant).--A plant species living and growing for only 1 year or season.

Aquifer.--An underground zone of earth or rock saturated with water whose upper limit is the water table.

AUM.--See Animal unit month.

Biennial (plant).--A plant species that completes its life cycle, from seed germination to seed production, in 2 years. Also means "to occur every 2 years," as in biennial burns.

Bioaccumulation.--The process of a plant or animal selectively taking in or storing a persistent substance. Over a period of time, a higher concentration of the substance is found in the organism than in the organism's environment.

Biological control.--Pest control without the use of chemicals. Parasites, predators, diseases, etc. are used to control pests.

Biological opinion.--An official report by the Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) issued in response to a formal Forest Service request for consultation or conference. It states whether an action is likely to result in jeopardy to a species or adverse modification of its critical habitat.

Biomass.--The total amount (weight) of living material in a given habitat.

Broadcast application.--Uniform distribution of an herbicide over an entire area.

Broadleaf weed.--A nonwoody dicotyledonous plant with wide bladed leaves designated as a pest species in gardens, farms, or forests.

Browse.--That part of leaf and twig growth of shrubs, woody vines, and trees on whic browsing animals can feed; to consume browse.

Buffer strip.--A strip of vegetation that is left unmanaged or is managed to reduce the impact that a treatment or action on one area would have on an adjacent area.

Canopy.--The cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.

Carcinogenic.--Producing or inciting cancer.

Chemical degradation.--The breakdown of a chemical substance into simpler components through chemical reactions.

Chronic toxicity.--How poisonous a pesticide is to an animal (or man) after small, repeated doses over a period of time.

Class I area.--One of three classes of areas provided for in the Clean Air Act for the Prevention of Significant Deterioration program. Class I areas are the "cleanest" and receive special visibility protection. They are allowed very limite increases (increments) in concentrations of regulated pollutants in the ambient air over baseline concentrations. (See 42 U.S.C. 7473 for description of the specific increments).

Conifer.--An order of the Gymnospermae, comprising a wide range of trees, mostly evergreens that bear cones and have needle-shaped or scalelike leaves; timber commercially identified as softwood.

Deciduous.--Pertaining to any plant organ or group of organs that is shed naturall perennial plants that are leafless for some time during the year.

Diversity.--The distribution and abundance of different plant and animal communiti and species within the area covered by a land and resource management plan.

Dose.--The amount of chemical administered or received by an organism, generally given point in time.

Drift.--That portion of a sprayed chemical that is moved by wind off a target sit

Duff.--The lower portion of the organic layer covering the soil, consisting of decomposed litter.

Ecological niche.--The physical space in a habitat occupied by an organism; its functional role in a community; and its position in environmental gradients of temperature, moisture, pH, soil, and other conditions of existence.

Ecosystem.--The system formed by the interaction of a group of organisms and their environment.

Ecotone.--The place where plant communities meet or where successional stages of vegetative conditions within plant communities come together; for example, a forest edge.

Edge.--The more or less well-defined boundary between two or more elements of the environment; for example, field/woodland.

Endangered species.--Any species that is in danger of extinction throughout all or a significant part of its range. Endangered species must be designated in the Federal Register by the appropriate Secretary. (See Threatened species.)

Ephemeral stream.--A stream that flows less than 10 percent of the time, only in direct response to rainfall, with a channel that may be scoured or unscoured and is always above the water table.

Ester.--A compound formed by the reaction of an acid and an alcohol, generally accompanied by the elimination of water.

Exposure.--The amount of contact with a pesticide.

FIFRA.--Federal Insecticide, Fungicide and Rodenticide Act (1948, amended 1972, 1975, 1978).

Forage.--All browse and nonwoody plants available to livestock or wildlife for grazing or harvested for feed.

Forb.--Any herbaceous plant other than grass or grasslike plants.

Foreground.--A term used in visual resource management to describe the visible terrain in which individual details of the landscape can be perceived, usually up to 1/4-1/2 mile from the observer.

Formulation.--The form in which a pesticide is packaged or prepared for use. A chemical mixture that includes a certain percentage of active ingredient (technical chemical) with an inert carrier.

Fuel.--Living or dead plant material that will burn.

Habitat.--The natural environment of a plant or animal. An animal's habitat includes the total environmental conditions for food, cover, and water within its home range.

Half-life.--The time required for half the amount of substance (such as a herbicide) in or introduced into a living system to be eliminated whether by excretion, metabolic decomposition, or other natural process.

Hardwood-pine.--Stands in which 51-69 percent of the crowns in the dominant and codominant position are hardwoods.

Hardwood stands.--Stands in which 70 percent or more of the crowns in the dominant and codominant position are hardwoods.

Hazard.--The risk of danger; the chance that danger or harm will come to the applicator, bystanders, consumers, livestock, wildlife or crops, etc.

Herbaceous.--A plant that does not develop persistent woody tissue above the ground (annual, biennial, or perennial), but whose aerial portion naturally dies back to the ground at the end of a growing season. They include such categories as grasses, grass-likes (sedges, rushes), and forbes.

Herbicide.--A chemical used to control, suppress, or kill plants, or to severely interrupt their normal growth processes.

Hydrolysis.--Decomposition or alteration of a chemical substance by water.

Inert ingredients.--All ingredients in a forumlated pesticide product which are not classified as active ingredients. Note that inert as used here is a defined usage; many inert products are biologically active chemicals.

Intermittent Stream.--A stream that flows seasonally (10-90 percent of the time) in response to a fluctuating water table, with a scoured channel that is at least 3 fee wide.

Label.--All printed material on or attached to a pesticide container as required by law.

Landtype.--A land area with distinct topography, geology, and runoff-erosion respons to management.

LC$_{50}$.--See Lethal concentration$_{50}$.

LD$_{50}$.--See Lethal dose$_{50}$.

Lethal concentration$_{50}$(LC$_{50}$).--The concentration of a chemical at which 50 percent the test animals will be killed. It is usually used in testing of fish or other aquatic animals.

Lethal dose$_{50}$(LD$_{50}$).--Median lethal dose, is the milligram of toxicant per kilogra of animal body weight (mg/kg) lethal to 50 percent of the test animals to which it administered under the conditions of the experiment.

Median lethal dose, is the milligram of toxicant per kilogram of animal body weig (mg/kg) lethal to 50 percent of the test animals to which it is administered unde the conditions of the experiment.

Litter.--The upper portion of the organic layer covering the soil, consisting of unaltered dead remains of plants and animals whose original form is still visibl

Margin of safety (MOS).--The ratio between the animal no observed effect level (and the estimated human dose. The larger the MOS, the smaller the estimated hum dose and the lower the risk to human health.

Meristem.--The growing point or area of rapidly dividing cells at the tip of a stem, root, or branch.

Microbial degradation.--The breakdown of a chemical substance into similer components by bacteria.

Multiple use.--The management of all the various renewable surface resources of the National Forest System so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some lands will be used for less than all of the resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of the uses that will give the greatest dollar return or the greatest unit output.

Mutagenicity.--The capacity of a substance to cause changes in genetic material.

National Environmental Policy Act (NEPA).--Establishes a national policy to encourage productive and enjoyable harmony between man and the environment, to promote efforts that will prevent or eliminate damage to the environment and stimulate the health and welfare of man, to enrich the understanding of the ecological systems and natural resources important to the nation, and to establish a Council on Environmental Quality.

National forest land and resource management plan.--A plan developed to meet the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended (95-125, 129, 130). This plan guides all natural resource management activities, and establishes management activities, standards, and guidelines for each national forest.

Natural regeneration.--The renewal of a tree crop by natural means, or without efforts to seed or plant trees. The new trees grow from selfsown seeds or by vegetative means such as root suckers.

NEPA.--See National Environmental Policy Act.

NOEL.--See No-observed-effect-level.

Nontarget.--Any plant, animal, or other organism that a method application is not aimed at, but may acciently be injured by the method.

No-observed-effect-level (NOEL).--In a series of dose levels tested, it is the highest level at which no effect is observed.

Noxious weed.--A plant regulated or identified by law as being undesirable, troublesome, and difficult to control.

Oncogenicity.--Capable of producing or inducing tumors in animals, either benign (noncancerous) or malignant (cancerous).

Opportunity cost.--The net loss, expressed in dollars, resulting from the selection of a less efficient course of action.

Perennial.--A plant species having a lifespan of more than 2 years.

Perennial stream.--A stream that flows year-round (more than 90 percent of the time) with a scoured channel that is always below the water table.

Persistence.--The resistance of a herbicide to metabolism and environmental degradation and thus a herbicide's retention of its ability to kill plants for prolonged periods.

Pesticide.--Any substance or mixture of substances intended for controlling insects, rodents, fungi, weeds, or other forms of plant or animal life that are considered to be pests.

Photodecomposition.--The breakdown of a substance, especially a chemical compound, into simpler components by the action of radiant energy.

Photosynthesis.--Formation of carbohydrates in the tissues of plants exposed to ligh

Pine-hardwood stands.--Stands in which 51-69 percent of the crowns in the dominant and codominant position are softwood species.

Pine stands.--Stands in which 70 percent or more of the crowns in the dominant and codominant position are softwoods.

Plant community.--An association of plants of various species found growing togethe in different areas with similar site characteristics.

Plastic soils.--Soils having enough clay or silt so that it can be compacted by applying pressure when the moisture content exceeds the level known as the plastic limit.

Pocosin.--An evergreen shrub bog on a raised plateau, usually removed from large streams yet periodically flooded, with acid, poor sandy or peat soils, in the Atlantic flatwoods (Algonquin: "swamp on a hill").

Poison.--Any chemical or agent that can cause illness or death when eaten, absorbe through the skin, inhaled, or otherwise absorbed by man, animals, or plants. Note that a substance is a poison or not with respect to specific organisms. Animals safely eat many things which are "poisonous" to humans.

Precommercial thinning.--Cutting in immature stands to improve the quality and gr of the remaining stand. None of the felled trees are extracted and utilized.

Protocol.--see Standard.

Pyrolysis.--Chemical breakdown caused in the process of combustion.

Regeneration.--The renewal of a tree crop whether by natural or artificial means Also, the young crop itself.

Release and weeding.--All work done to free desirable trees from competition wit overstory trees, less desirable trees or grasses, and other forms of vegetative growth. It includes incidental disease control work and release of natural and artificial regeneration.

Residue.--The quantity of a herbicide or its metabolites remaining in or on soil, water, plants, animals, or surfaces.

Rhizomes.--A stem, generally modified for storing food materials, that grows along and below the ground surface and that produces adventitious roots, scale leaves, and suckers irregularly along its length, not just at nodes.

Riparian ecosystem.--A riparian ecosystem is a transition between the aquatic ecosystem and the adjacent terrestrial ecosystem and is identified by soil characteristics and distinctive vegetation communities that require free or unbound water.

Risk.--The probability that a substance will produce harm under specified conditions.

Risk analysis.--The description of the nature and often the magnitude of risk to organisms, including attendant uncertainty.

Rotation.--The number of years required to establish and grow a timber crop to a specified condition of maturity. The rotation includes a period for harvesting and stand re-establishment, usually 5 years.

Safety factor.--A factor conventionally used to extrapolate human tolerances for chemical agents from no-observed-effect levels in animal test data.

Scoping.--The process by which significant issues relating to a proposal are identified for environmental analysis. Scoping includes eliciting public comment on the proposal, evaluating concerns, and developing alternatives for consideration.

Sensitive Species.--Those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by: significant current or predicted downward trends in population numbers or density; or significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution.

Shrub.--A plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form.

Silviculture.--The branch of forestry dealing with the care, development, and reproduction of forest trees or stands of timber.

Site preparation.--The removal of competition (including woody slash) and conditioning of the soil to enhance the survival and growth of seedlings or to enhance the germination of seed.

Snag.--A standing dead tree.

Species (plural: species).--A morphologically, genetically, and ecologically defined biological entity to which a binomial and authority is given; e.g., Potamogeton filiformis Pers., the slender-leaf Potamogeton.

Stand.--Trees that grow in the same location, and which are fairly uniform in type, age and risk classes, vigor, stand-size class, and stocking class. The similarity of these qualities distinguish the stand from adjacent stands that contain trees with different features.

Standard.--A principle requiring a specific level of attainment; a rule to measure against.

Subchronic.--The effects observed from doses that are of intermediate duration, usually 3 months.

Succession.--The progressive development of trees or other plants toward their highest role in their ecology; their climax. The replacement of one forest, or other plants, by others.

Technical chemical or pesticide.--The pesticide as it is first manufactured by the company before formulation. It is usually almost pure.

Teratogenesis.--The development of abnormal structures in an embryo.

Threshold.--A dose or exposure below which there is no apparent or measurable adverse effect.

Threshold limit value (TLV).--The concentration of an airborne constituent to which workers may be exposed repeatedly, day by day, without adverse effect.

Timber stand improvement (TSI).--Activities conducted in young stands of timber to improve growth rate and form of the remaining trees, includes release and precommercial thinning.

TLV.--See Threshold limit value.

Toxicity.--A characteristic of a substance that makes it poisonous.

TSI.--See Timber stand improvement.

Understory (vegetation).--Shade-tolerant plants growing below the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or brush canopy.

Visual resource.--The composite of basic terrain, geologic features, water features vegetative patterns, and land-use effects that typify a land unit and influence the visual appeal the unit may have for visitors.

Watershed.--The entire area that contributes water to a stream or lake.

Wetlands.--Those areas that are inundated by surface or ground water often enough support plants and other aquatic life that requires saturated or seasonally satura soils for growth and reproduction. Wetlands generally include swamps, marshes, bo and similar areas such as sloughs, potholes, wet meadows, river overflows, mud fla and natural ponds.

WSI.--See Wildlife Stand Improvement.

Wildlife Stand Improvement (WSI).--Activities conducted in timber stands to impro conditions for various wildlife species. Includes release and midstory removal.

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CHAPTER VIII

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